OMNI

02484
FEBRUARY 1984 $2.50

FINDING GOD IN AN ATOM
WEIRD LAB ANIMALS • OLYMPICS 2084
TAPING ALTERNATE UNIVERSES

OMNI®

VOL 6 NO 5 FEBRUARY 1984

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Ellen Schuster, owner of Elle Studio, in Dallas, is an advertising photographer. In this picture, commissioned by Classic Color Engravers, she utilizes two archetypal images—the egg and the butterfly—to symbolize the possibility of change

OMNI (ISSN 0149-8711) is published monthly in the United States and Canada by Omni Publications International Ltd., 1965 Broadway, New York, NY 10023-5965. Second-class postage paid at New York, NY, and at additional mailing offices. POSTMASTER: Send address changes to Omni Magazine, 80 New Bridge Road, Bergenfield, N.J. 07621. Volume 6, Number 5. Tel. (212) 496-6100. OMNI is a registered trademark of Omni Publications International Ltd. Printed in the U.S.A. by Meredith Printing Corp. and distributed in the U.S.A., Canada, U.S. territorial possessions and the world (except the U.K.) by Curtis Circulation Company, 21 Henderson Drive, West Caldwell, N.J. 07006. Distributed in the U.K. by COMAG, Tavistock Road, West Drayton, London UB7 7QE England. Subscriptions U.S., APO—$24 one year. Canada and elsewhere—$34 one year. Single copies $2.50 in U.S., APO and Canada. Telephone 1-800-247-5470, in Iowa 1-800-532-1272.

FIRST WORD

By Rawson Stovall

"Taking your anger out on the objects on a video screen is much better than taking it out on a real, live person"

A recent slump felt by many companies in the video-game industry does not mean that this form of entertainment is on its way out. Far from it! These may be confusing times for the industry and the consumer, but this awesome technological revolution continues. The benefits of the video-game industry have lately been clouded over by so much negative talk. That's why I'd like to discuss the positive aspects of video games.

During the past year, I've been interviewed at least 50 times by members of various media. A favorite question is either, "What about the violence in video games?" or, as Morton Dean of *CBS Morning News* asked me, "Are video games good for kids?"

I'd like to ask, "What's so bad about them?" By video games, I mean coin-op games that are found in arcades, and games designed for play on home game systems. These games give kids and grown-ups a chance to act out their dreams, allowing players the opportunity to act like deep-jungle explorers, jet fighter pilots, or dragon slayers. Video games are, in my opinion, much better than television, because they allow a player to interact. The player analyzes the situation, considers the responses, chooses one, and solves the problem. The basic concept is always the same—be it an attack from an alien invader or from an educational math game.

Now to the question of violence in video games. I'll agree that there's lots of it, from blowing up army tanks or zapping alien invaders to massacring helpless robots. But have you watched Saturday-morning cartoons or prime-time television lately? What's so tame about Wile E. Coyote using nitroglycerin and dynamite in hopes of getting a Road Runner dinner?

Personally, I see nothing wrong with a little violence, whether it's in video games or television shows. Playing a game where I'm blasting foreign-looking objects helps me get rid of some of my frustrations. Taking your anger out on the objects on a video screen is much better than taking it out on a real, live person.

It is true that both arcade and home games have emphasized violent themes such as those found in space shoot-'em-up games. But now there is a trend toward educational/strategy/thinking-type games. Companies like Atari, Mattel, and Activision have all developed and marketed games recently that can be considered lessons in themselves. There are educational games even for arcades. One example is *Exidy's Fax*, a knowledge-challenging game consisting of 900 questions in each of four categories: sports, trivia, history, and entertainment.

Sure, I've heard reports that some parents are afraid their kids will overdo the games and spend too much time and money on them. They said the same thing about pool halls and pinball for my grandparents. But I personally don't know anyone who neglects schoolwork, chores, and other responsibilities because of video games. My friends seem to be too involved in sports, music, church, and scouting activities to be able to play for more than a few hours each week. In fact, a recent study conducted by *The News Sentinel*—a Fort Wayne, Indiana, newspaper—shows that my friends are not alone. That survey indicates that 42 percent of polled middle-school students spend less than an hour a week playing, and only 11 percent play for more than six hours a week.

And what's so terrible about occasionally overdoing the game? Everyone overdoes something now and then. I happen to side with Erma Bombeck when she writes, "Frankly, I don't see video games as being any more mind-controlling than their fathers sitting spellbound before 86 football games a week or their mothers mesmerized by four hours of soaps a day." Sports broadcasts and soap operas must be filling a big void in the lives of grown-ups, or they wouldn't be investing so much time and energy in them. Maybe it's that way with kids, too, or maybe they're just plain bored.

Last, and most important, is that video games are helping kids discover computers. After buying my game system when I was in the fourth grade and playing all the games I could get my hands on, I desperately wanted to see my own ideas on a screen. A friend and I had a notebook full of descriptions of games and original drawings, and we were planning to go into business together. But our excitement soon soured because we couldn't get anyone to listen to us. We found that some companies would look at programmed games, but not just at illustrations and visual ideas.

We realized we needed programming skills and a computer. Since the pecan season had passed (selling them was how I made the money to buy my first game system), I looked around for another way to make money to get a computer, so I started writing game reviews for *The Abilene Reporter-News*, my hometown paper, and then gradually for others.

If I had three wishes, one would be for the media to stay away from the video-game subject for a while, or at least look at its positive effects. My second wish is that video critics would get on to some more important things, like getting computers into schools and training teachers how to use them. My third wish is that parents who are so opposed to video games would actually get involved in playing these games. They just might discover a whole new world of fun they could share with their kids. OO

Rawson Stovall's weekly column, "The Vid Kid," is syndicated nationally by Universal Press Syndicate. He is twelve years old and lives in Abilene, Texas.

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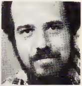


KENDIG

Over the last decade the use of animals in the lab has dropped some 40 percent according to the National Academy of Sciences The trend results partly from efforts to cut research costs—animals are expensive to keep—and partly from the efforts of animal-rights advocates But the spokespeople for nonhumans tend to be selective in their efforts They generally stand up for those creatures who look and act most human

That includes chimps—venerable animal allies in medical and psychological research—and rabbits with their softly alluring eyes So far at least there have been few lobbyists for the bat the turtle the sand rat and the armadillo But as we report in 'Guinea Pigs,' each of these unsung heroes has contributed to the advancement of science. On page 46 freelance writers *Frank Kendig* and *Lisa Buck* pay overdue respects to the exotic members of the laboratory menagerie And our reporters explain why these species are prized in neural, cardiovascular and immunodeficiency research as well as other fields

Frank Kendig was *Omni's* first executive editor and now devotes all his time to writing Buck, a former student of Kendig's at Syracuse University works with him on many projects

In other labs the 'creatures at the focus of research are unimaginably large Yet with the help of tiny silicon chips and fancy electronics the subjects under study—entire clouds of galaxies—are shrunk to the size of a television screen Some of today s astronomers seldom look through a telescope Instead they watch video screen pictures of stars moving with a kind of computer hyperdrive through seas of distant suns On the screen a portion of the cosmos appears neon-green then red hot pink and finally iridescent yellow, as it bursts into a thousand dots The screen clears then refills with brilliantly colored specks of ruby amethyst, diamond and topaz This video kaleidoscope is standard fare at one of astronomy s newest installations, the Image Processing Facility at the Harvard-Smithsonian Center for Astrophysics in Cambridge Massachusetts In 'Astrovideo' on page 50 freelance writer *Richard Wolkomir* presents an inside look at how computers are revolutionizing celestial exploration 'Using the imaging system,' Wolkomir says astronomers can store, manipulate analyze and reproduce data with a power that was inconceivable just a decade ago Silicon chips have replaced photographic plates for observing distant objects in space And astronomy will never be the same again

On page 40 Wolkomir turns to other alien worlds—those inside the atom In 'Quark City' he provides a friendly introduction to the scientific quest for the basic components of all things from animals to distant stars

Wolkomir s assignment took him to FermiLab in Batavia Illinois where physicists are whipping particles around a subterranean tunnel then forcing them to collide In the high-energy smashup particles disintegrate into primordial raw forms of matter For fractions of a second scientists re create the world that existed immediately after the Big Bang when the universe was born At FermiLab and other centers around the world researchers are looking for an equation that will sum up creation As one scientist says We hope to explain the universe in a single formula you can wear on your T-shirt '

But the task of describing the stuff of matter is not easy For example, who can explain the rising and falling of the Nile, or the shapes of clouds and craters? Benoit Mandelbrot can Some 25 years ago amid charges of heresy, the IBM mathematician and philosopher proposed a theory of fractals to explain phenomena that would not fit into the abstract purity of Euclidean geometry Our Interview, which begins on page 64 was conducted by *Monte Davis* who shows how Mandelbrot has changed the way scientists view reality

Our fiction offering this month comes from *Lewis Shiner*, a young writer from Austin Texas who has been published in all the major science-fiction magazines In 'Deserted Cities of the Heart' (page 68), scientists investigating ancient Mayan culture arrive at a startling conclusion about the present and future **OO**

LETTERS

COMMUNICATIONS

Premature Party

In the Antimatter article "Millennium Ball" [November 1983], Ed McNally, the president of the Millennium Society, tells of a 1999 New Year's Eve bash to celebrate the long-awaited arrival of the new millennium. I regret to inform Mr McNally that all of his $6,000 invitations will have to be recalled. The new millennium will not arrive until New Year's Eve of the year 2000. This is because there was never a 0 A.D.: the second year began on New Year's Eve at the end of year two.

Robert Fein
Bronx, NY

Opposite Directions

It was with no little amusement, mixed with even greater amazement, that I read Richard Marquand's self-aggrandizing remarks in Mitch Tuchman's Film column regarding his direction of *Return of the Jedi* [June 1983].

Considering his less-than-spectacular track record, I suppose I can understand his loss of ego control when George Lucas tapped him for this assignment.

However, I cannot understand his uncharitable remarks about the four actors in the film. His allegation that the actors had told him, "We are a club of a small number of very important people, and you are now an honorary member," is patently false. Not only did this conversation never transpire, the atmosphere of clannishness that Marquand alludes to was nonexistent. Any perception by Marquand to the contrary can be attributed only to his own paranoia engendered by personal misgivings about his ability to handle the responsibility that Lucas put in his care.

In my opinion, Marquand failed miserably in his given task. It is virtually impossible to kill a *Star Wars* movie, but Marquand certainly gave it a good try.

Patricia McQueeney
Harrison Ford Productions
Los Angeles

Whatever might be said about Richard Marquand as a director, it can certainly be affirmed that the *Star Wars* saga benefited tremendously from his addition of humanity and three-dimensional characters to *Return of the Jedi*. I'm wondering if George Lucas and his future directors might opt for more three-dimensional scripts to go along with this innovation. I certainly hope so. I believe that films should challenge the imagination as well as the senses.

Jonathan Lowe
Greenville, SC

Theory Down for the Count

Responding to Mark S. Rafer's theory in the October issue [Competition #27] that "most of the current state of world affairs is the result of a massive social-science experiment being conducted by Stanley Milgram," who now "intends to study group dynamics during a world war," Milgram writes: Mr. Rafer's theory fails on three counts. 1) Nowadays funding is not available for studies of this magnitude. 2) I have no intention of starting World War III to study wartime dynamics. 3) In any case, the ethics-review panel at my university does not approve such studies unless the investigator obtains informed consent from the participants *in writing*. No such consent statements exist. Ergo, Rafer's theory cannot be true.

College Confusion

Recently one of our students brought the picture of our student center featured in Phenomena [August 1983] to my attention. What an unusual coincidence that the University of La Verne should have the same type of tents as the University of California at Irvine.

Could this possibly be a classic case of mistaken identity?

Patricia Centurione
Administrative Assistant
University of La Verne
San Diego

Editors' note: You are right, of course: the structures pictured were of the University of La Verne and not the University of California at Irvine. As you might imagine, once we discovered our error, our embarrassment was intents. **OO**

DIALOGUE

FORUM

Omni welcomes speculation, theories, commentary, dissent, and questions from readers in this open forum. We invite you to use this column to voice your hopes about the future and to contribute to the kind of informal dialogue that generates breakthroughs. Please note that we cannot return submissions and that the opinions expressed here are not necessarily those of the magazine.

Biblical Feminism

Rather than debate the translation error discussed in the article "Equality for Eve," by Sherry Baker [Antimatter, October 1983], I would like to remind your readers that (1) the Bible is a tool, a guide for living and for gaining understanding, and should not be used as a weapon to promote individuals' ideas, and (2) the inadequacy of any written language or particular translation is more than compensated for when one reads the Bible in the right spirit.

Those who take the time to read beyond the first few pages of Genesis will find additional material that increases the understanding of male/female relationships. For example, the description of the ideal wife in Prov. 31:10–31 may surprise those people who think the Scriptures are outdated. This proverb describes a wife who is gainfully employed, confident, talented, dignified, powerful, praiseworthy, and God-fearing. She makes real-estate investments, manages her business, teaches loyalty and wisdom, and is honored in her community. This is obviously a "model" for a full partner, not a subordinate doomed to suffer the "trapped housewife" syndrome.

D. Alan Eastwood
Poughkeepsie, NY

In the article "Equality for Eve," David Freedman was quoted and touted as a "religious archaeology and -language scholar." Perhaps he should stick to archaeology. I have taught Hebrew and Greek for many years at Dallas Christian College in Texas.

Freedman claims that *ezer*, as applied to Eve, should actually be interpreted as "a power" or "a strength." If he wants to interpret the word that way, he may for himself. However, the word does not mean that, and it is not translated so in English Bibles or any Hebrew lexicon. The word with that meaning is *azaz*. *Ezer*, according to the lexicons and translations, is correctly translated as "helper." The other word applied to Eve, *kenegdo*, means literally "according to what is in front of" or "corresponding to." The two words are actually to be taken together in a sexual connotation. Adam, in the second chapter of Genesis, names all the animals, and among them no "helper" is found who would "correspond to" Adam. In the account, God creates woman to be literally "a helper fit for the front of man." This passage, per se, says nothing about equality or inequality; it appears simply that man and woman "correspond to" each other.

If we look for "equality" in Gen. 1:26ff., there we find it, as well as in the statement of the much-maligned Apostle Paul in Gal. 3:26–28: "You are all *sons* of God through faith in Christ Jesus, for *all* of you who were baptized into Christ have been clothed with Christ. There is neither Jew nor Greek, slave nor free, *male nor female*, for you are all one in Christ Jesus."

Mark Berner
Dallas

Feeding the Future

I have never read so much trash as I did in Cyril Ponnamperuma's First Word in the September 1983 issue. This article belongs in a humor magazine, not in a terrific scientific publication like *Omni*.

The declaration that "food is the single most important requirement for life" is a misstatement at best. Man can live for quite a long period of time without food if he has water and fresh air.

The good professor never actually states the findings of the Commission on World Hunger but says that the United States should make the elimination of world hunger its main priority when dealing with Third World countries. He then tells us that by the year 2015, we will face a world population of about 8 billion people and that we will need 3 times the food we are currently producing to feed these people.

Well, I don't argue with his figures of the projected world population, but I disagree with him when he states that we will not be able to feed these people.

The world is currently producing plenty of food to feed the entire population. Our inability to feed everyone is due to economic rather than production problems. Millions of tons of food are destroyed or stored each year in order to keep market prices high.

To feed the world, we must deal with the problems of distribution. Hunger exists today because of geographical, religious, and economic reasons; it is not due to a lack of production capacity.

Guy Norman
Seoul, South Korea

Observing the Heavens

Omni's article "Merlin's Rock," in the September 1983 issue, captures the spirit and mystery surrounding Stonehenge on England's Salisbury Plain.

However, despite the implication in the article, I have never abandoned my theory that Stonehenge was an "astronomical observatory" in the sense that the sun and the moon could be seen through the archways. As I said in *Stonehenge Decoded*, "It [Stonehenge] could have formed a dramatic backdrop for watching the interchange between the sun, which dominated the warmth of summer, and the moon, which dominated the cold of winter." I stand by my statement.

Even with the poor climate in England today, the stones continue to function as astronomical markers. Meteorological records show that in 100 dawns a portion of the sun's disk can be clearly seen on 78 occasions. What is more, climate experts tell us that the weather was better at Stonehenge in 2000 B.C. than it is now.

In my opinion, Stonehenge was one example of the keen interest in the heavens that existed in prehistoric times.

Gerald Hawkins
Washington, DC

POLE-TO-POLE ODYSSEY

EXPLORATIONS

By Tonia Shoumatoff

One balmy day in 1972 Lady Virginia Twistleton-Wykenham Fiennes was spinning an eight-inch tin globe in her home in Barnes England She began tracing the Greenwich Meridian with her index finger and wondered out loud to her husband if anyone had ever traveled around the world along its path Never they decided Could she and Sir Ranulph Twistleton-Wykenham Fiennes do something that had never been done? Was there one more round-the-world race yet to challenge the Union Jack? The thirty-eight year old Sir Ranulph a bearded former army officer with a rugged but dashing air stared at his wife a faint smile on his lips The challenge was irresistible

High adventure was in Sir Ranulph's blood. In his family, whose roots go back to William the Conqueror younger sons had regularly been sent to colonize far-flung reaches of the British Empire Both his father and grandfather had been awarded many medals for bravery Sir Ranulph had always been enthralled by family accounts of his grandfather who after a period of fighting the Zulus in the best Kipling tradition had gone to Canada to become a trapper and, later a celebrated Mountie

All was not tea and crumpets for Sir Ranulph and Lady Fiennes though When *Omni* talked with them in New York eight months after their journey had ended Sir Ranulph explained how they overcame their first major obstacle—money 'Although I was born with a title I did not inherit the money to go along with it' Sir Ranulph said

But he did get Prince Charles heir to the British throne, to be the expedition's patron Prince Charles thought Sir Ranulph's proposed expedition 'absolutely mad' but marvelous. The Prince contacted Armand Hammer the eighty-six-year-old chairman of the board at Occidental Petroleum in the United States in whom the Prince knew the spirit of free enterprise always burned Hammer encouraged companies to support the expedition and established his own television-production company to record the journey

Sir Ranulph and Lady Fiennes's expedition was the first to traverse the world along its axis.

As the expedition began to take shape, Ran (Sir Ranulph) and Ginnie (Lady Fiennes) waxed more enthusiastic They would travel through Africa to the 1,000 unmapped miles of Antarctica cross it 'simply because it's there' and then push on to Australia and California—both out-of-the-way but necessary stops to promote their sponsors' products From California the expedition would head for Alaska and the devilish Northwest Passage to the Arctic. Ran, as expedition leader would head the core group that would cover every step of the journey Ginnie as base leader would be in charge of communications and supplies

The only criteria for expedition members were as Ginnie put it 'good nature, patience and of course a willingness to give up three years of their lives without pay' After screening the first 30 applicants Sir Ranulph settled on Oliver Shepard and Charles Burton, fellow British army men with no previous exploration experience In Sir Ranulph's official account of the Transglobe Expedition *To the Ends of the Earth* (Arbor House), he initially describes Shepard a fellow Etonian, as a paunchy and pompous beer salesman with a mild air of debauchery' But after testing Shepard's mettle in the Welsh mountains he was convinced that he had found 'the right stuff' Burton likewise seemed an unlikely expedition candidate appearing in a tweed overcoat and 'smoking a wicked briar' But his army experience along with a deliciously British sense of the absurd had given him a fierce determination More volunteers followed

When Marsh & McClennan, a leading insurance brokerage, and its British subsidiary C T Bowring & Company Ltd, donated the use of a vessel the *Benjamin Bowring* the group began making final plans Pieces of the improbable journey began to fall into place

On September 2, 1979 with Prince Charles at the helm, Sir Ranulph Lady Fiennes and companions from nine countries set sail from London Because of the tragic assassination of his great-uncle, Lord Mountbatten, a few days

CONTINUED ON PAGE 109

ARTIFICIAL INTELLIGENCE

By Peter Ognibene

The Internal Revenue Service has taken the past three years of your life and compressed them into 0.2 inch of magnetic tape. That is the average length of an individual taxpayer's master file at the agency's National Computer Center (NCC) in Martinsburg, West Virginia. If you paid income tax in the United States, the financial details you reported to the IRS now repose on one of 1,200 reels of magnetic tape.

Computers are so vital in the collection of funds that the IRS devotes at least 25 percent of its budget to data processing. This year a new generation of computers is at work 12 hours each business day, placing dunning calls to people who are late in paying taxes. In the near future IRS auditors will use similar technology against tax evaders.

At present, however, the master files of the IRS are anything but complete. Although the agency electronically encodes individual and business tax returns for its master files in Martinsburg, millions of important documents never enter the computerized tax-data stream. Much of the problem arises from the flood of paper that engulfs the IRS each year. In 1982, for example, the government received 170.4 million tax returns and collected $632.2 billion.

In addition to tax returns, the IRS also received 664 million "information documents," such as W-2 forms for wages and 1099 forms for interest, dividends, and other income. Although these documents are the key to catching people who fail to report all their income, much of the information never becomes part of the computerized master files.

The problem is one of manpower. The IRS simply does not have enough people to transfer all the information documents from paper to magnetic tape. Based on IRS data, it appears that about 308 million of the 664 million information documents received in 1982 will never enter the master files of the NCC.

Can these gaps be closed? "I think the ultimate answer to our problem is a totally integrated [electronic] system," says M. Eddie Heironimus, the revenue service's associate commissioner in charge of data processing.

Though Heironimus may be right, the IRS is unlikely to get such a system. In the mid-Seventies, for instance, the agency proposed that all its computers be linked together electronically. But Congress, still haunted by the specter of Watergate and President Nixon's "enemies list," vetoed the idea, fearing that such a data file might one day be misused by an unscrupulous chief executive and his administration.

The congressional decision prompted a panel of the National Research Council to observe, "Perhaps it is proper that the IRS must struggle disproportionately hard to apprehend tax evaders in order to avoid tightening things so completely for all honest taxpayers that the system would resemble the Big Brotherism of Orwell's *1984*."

So inefficiency has been intentionally built into the agency's data-processing network. The Treasury Department has specified, for instance, that the tax-data stream must have at least two physical breaks between IRS field offices and the NCC. Instead of transmitting information by wire, the IRS must package and ship computer tapes to and from the NCC. When the spring flood of tax returns hits local IRS offices, Martinsburg handles up to 6,500 computer tapes a week.

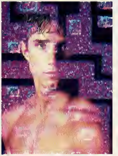
One advantage of a fragmented system is that it presents an obstacle to Big Brother's snooping. No one can just sit down at a computer terminal in a local IRS office and tap directly into the agency's master files to get information about a taxpayer. The data must be requisitioned by the local center and physically retrieved by officials at the NCC.

Rather than integrating all its computers, the IRS is concentrating on making individual operations, such as collecting back taxes, more efficient. The old system, says Heironimus, "was a paperwork nightmare. We spent more time moving paper around than we did taking action to collect the taxes."

Some of that paperwork barrier began to crumble with the introduction of the Automated Collection System (ACS) in May 1983. Heironimus calls ACS "a computer-driven telephone system." That bland description fails to capture the real purpose of ACS, which is to extend the electronic tendrils of the IRS into the homes and businesses of anyone who fails to pay his taxes on time.

A taxpayer becomes a "delinquent account" if he does not pay his taxes in full by April 15. The IRS then begins sending him computer-generated letters demanding payment; high interest charges are added daily to the unpaid taxes. In 1982 the IRS assessed 26.3 million penalties, totaling $5.1 billion.

The IRS sends up to four notices by mail. If the person fails to respond, his account is turned over to ACS. From eight in the morning until eight at night every weekday and from eight until noon on Saturdays, clerks sit in front of computer terminals and conduct an electronic assault on delinquent taxpayers.



The tax man cometh—with a hungry computer

CONTINUED ON PAGE 84

LIFE

By Lindsy Van Gelder

It was one of those ideas that probably sounded like an exploding light bulb at the time: dating services for victims of genital herpes, a way for the estimated 20 million Americans who suffer from the incurable sexual virus to connect with one another. As such medical matchmakers sprouted all over the country during the past year, the idea spread to the personal ads (BRIGHT, ATTRACTIVE WOMAN WITH FONDNESS FOR WOODY ALLEN, GREAT BACKHAND, AND HERPES SEEKS MALE COUNTERPART) and to many less formal searches for love. Finding someone else who shared the disease would neatly sidestep the problem of rejection and the fear of infecting a loved one—or so the reasoning went.

Then, last August, in a letter to the *Journal of the American Medical Association*, two dermatology professors in Chicago blasted the dating service phenomenon. "In our opinion," wrote Dr. Benjamin Raab, of the Northwestern University Medical Center, and Dr. Allen L. Lorincz, of the University of Chicago School of Medicine, "such services are not only unnecessary but they actually may be detrimental from both medical and psychosocial points of view."

The medical problem with the dating services, according to Drs. Raab and Lorincz, is that genital herpes can be caused by both the Type 2 virus (which typically finds a home in the nerve cells connecting the genitals and the spinal cord) and the Type 1 virus (which causes the common facial cold sore). Although Type 2 is a more severe virus and the one usually associated with genital herpes, the popularity of oral sex has contributed to passing on a fair amount of the Type 1 virus to the genitals. Type 2 can, in turn, be passed to the mouth and cause a severe infection. And even within the two virus types, the doctors pointed out, there are "numerous genetically different strains."

In other words, when two people with herpes make love, "the possibility could exist for transmission of a different virus from one partner to another, with a possible increased recurrence rate." Tests to determine which strain a person carries are done only at university laboratories and aren't commercially available.

Beyond setting people up to infect one another, the physicians charged, herpes dating services exploit "herpes hysteria" and perpetuate the notion that "restricted personal relationships represent the only social option available to patients with herpes." In fact, Raab explains, "the whole scarlet letter thing is blown out of proportion, because it's just not difficult to reduce the chances of spreading herpes." Using spermicidal foam and condoms and abstaining from sex during outbreaks of herpes lesions, he says, "won't protect you one hundred percent, but it's pretty close."

Although Steven Sherbel, a psychologist who runs the Detroit- and New York-based herpes dating service Confidant, agrees that herpes can be contained medically with the proper precautions, he believes dating services are simply dealing with a problem, not promoting the hysteria. "Seventy percent of the people who have herpes report feelings of social isolation," he explains, "and the unfortunate social reality of herpes is that they're likely to be rejected by potential partners."

Fear of rejection is what often sends herpes victims to the dating services. "Vicki," for instance, a thirty-four-year-old Los Angeles public-relations woman, separated from her husband two years ago and contracted herpes from the first man she encountered as a single woman. After a period of celibacy, she resumed dating, but her life back in the singles market was plagued by frequent herpes outbreaks—which she now attributes to anxiety—and by men who "could be cruel and cold when I told them I had herpes." Not long ago she enrolled (for $75) in the Herpes Network and has had dates with three men.

The first two didn't click, but the third "is magic." Her boyfriend and she share more than a virus, she says. "The funny part," she adds, "is that even though he's everything I've always liked in a man, I never would have had the chance to meet him if it hadn't been for herpes." OO

Herpes victims who turn to dating services may wind up making their disease even worse.

CONTINUUM

THE CASE FOR RADICAL SCIENCE

If the spate of new science magazines and popular TV shows like *Cosmos* has achieved anything, certainly it has shattered the old stereotype of the scientist. Where we once had Victor Frankenstein driven to megalomania in his secluded laboratory, we now have Carl Sagan discussing relativity as he tools around Italy on a bicycle. Men and women who do science are just folks after all. They are accessible, they are fallible, and they tend not to wear white coats.

But now, even though the white coat has slipped off the shoulders of the scientist, it still drapes the enterprise of science as a whole, shrouding many a biased theory or bigoted experiment in a cloak of objectivity. Indeed, according to members of the radical-science movement, millions of readers and viewers who have opened their arms to science are getting only a fraction of any story. The popular press, they say, presents new discoveries with "golly gee" enthusiasm, while totally ignoring the underlying motives and values of science.

The questions a scientist chooses to ask, after all, are not shaped purely by the facts of life or the evidence of physics. Instead, they may have much to do with the scientist's own gut-level assumptions, or with the source of his research funds. If the support for certain I.Q. studies, for example, is found to come from racist foundations, are the findings to be treated just like any other data?

Such a question might never come up in a newspaper or magazine account of the work, but it would be the focal point of any article in one of the half-dozen small-circulation radical-science journals. Scattered about the world, these periodicals are struggling against bankruptcy and anonymity, trying to show that science is not just a body of neutral truths.

"People tend to think science stands outside society," complains Bob Young, an editor of the ten-year-old *Radical Science Journal*, published in England. "But we look at science just like any other form of work. It's a labor process." In fact, though the "factories" investigated by these journals range from nuclear-power plants to genetic-engineering labs, the points raised are basically political. What are the limits of public participation in science? What are the effects of patenting research?

Radical Science Journal, published more or less annually from its offices at 26 Freegrove Road in London, has 2,500 subscribers living mostly in England and North America. With its lengthy analyses of the ideology and practice of science (it publishes such articles as "Feminist Critique of Science" and "New Left Interpretations of Seventeenth-Century Science"), the journal cannot hope for mass appeal, but staff members have worked with other organizations to produce a series of books and prime-time television documentaries with a broader reach. One of the volumes, called *Science or Society?*, investigates the political implications of scientific research. Another, *Out of Our Hands*, looks at what technology does to pregnancy.

And *Radical Science Journal* isn't alone. Other European counterparts include Italy's *Sapere*, West Germany's *Wechselwirkung*, and Holland's *Revoluon*. And in the United States a magazine called *Science for the People* is published by the Boston-based organization of the same name, reaching about 3,000 subscribers when it appears every other month. Born in 1968 out of the protest against the involvement of American scientists and engineers in the Vietnam War, one of the magazine's major goals is documenting corporate, governmental, and academic abuses of science.

"Our overall orientation is at the grass-roots level," explains Jon Beckwith, a Harvard geneticist who joined Science for the People in 1971. "We like to work with high-school teachers, and we get involved in community struggles." The Long Island, New York, chapter, for example, is fighting the pesticide Temik, which has poisoned so much of the groundwater in Suffolk County; members have also protested the construction of the nuclear-power plant at Shoreham and testified at government hearings on recombinant-DNA research.

The magazine reports on member activities, but also accepts outside articles on the social and political forces inherent in science, says Beckwith. Since so many of the subscribers are high-school and college teachers, the stories frequently wind up in classrooms, where they enjoy greater impact than the small readership would suggest. Recently the New Jersey education department distributed a *Science for the People* article about women and math to every math teacher in the state.

"Ideally," concludes Beckwith, "our business is empowering people to feel they can have control over issues often presented as too complicated for them to understand."—*DAVA SOBEL*

CONTINUUM

RAT SONAR

Like its distant relative the bat, the Norway rat, according to a recent study can echolocate in the dark charting its course through the night by emitting "sniff whistles" and teeth-chattering sounds that bounce off nearby objects

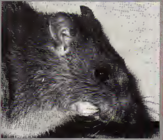
To learn the navigational secrets of this common laboratory rodent Barnard College biologist Julia Chase first demonstrated that rats with plugged ears couldn't run a Y-shaped maze in the dark (Without earplugs they dashed through easily) She then realized that she could hear the rats chattering though it took special sound equipment to pick up the faint sniff whistle The 8-kHz noise she finally found is pitched to the very frequency that owls the rats' most fearsome predators find hard to detect

Chase also learned that the rats emit different sounds under different circumstances The subtle whistle sound is used for short distances, and the chattering for longer ones Chase's subjects sniff-whistled when they faced the nearby walls of an experimental setup, but chattered when facing the distant one

Perhaps echolocation is one reason for this species' success in colonizing most of the globe says Chase "An opportunist like the Norway rat needs a whole arsenal of sensory and neurological equipment for getting around"

—Barbara Ford

"Rob a man of his subterfuge and he goes mad"
—*Ingmar Bergman*



The opportunistic Norway rat. A sniff whistle is used to echolocate over short distances chattering serves for longer treks

STAGE FRIGHT

It is a rare performer who has never suffered from the trembling hands pounding heart sweating palms, knocking knees failing memory and nausea of stage fright

Long experience in front of audiences is no cure, as many aging musicians will tell you and even international acclaim could not keep Pablo Casals, for example from suffering nightmares about public performance Alcohol and tranquillizers may quell the symptoms, but they often quash the performance as well

According to a research team made up of two physicians and one musician, however there is a medical solution to the stage-fright plight The drug propranolol, used widely in treating cardiac conditions removed the discomforts of stage fright in performers from the New York Philharmonic Orchestra, while improving the overall quality of their performances Charles Brantigan, Thomas Brantigan, and Neil Joseph report in *The American Journal of Medicine* that propranolol achieves these effects by blocking the body's beta receptors—sites in the nervous system where adrenaline binds and sets the "fight or flight" reaction in motion

"A performer beset by fear finds his body reacting as it would when facing a hostile mob or a saber-toothed tiger," they say, "but what is good for fighting tigers or a hostile mob is not necessarily good for performing music"

Several of the research subjects were enthusiastic in their praise of propranolol's effects but the authors caution that the drug can be lethal for anyone with asthma or certain heart anomalies, and that withdrawal after prolonged,

Pablo Casals He suffered the agony of stage fright

continuous use may be hazardous They recommend that musicians try it only under medical supervision for isolated episodes of severe stress such as a major recital —Dava Sobel

NEW PAIN KILLER

It's been known for years that tryptophan an amino acid found in milk, can help put you to sleep But now research coming out of Temple University, in Philadelphia, indicates that

tryptophan's benefits may be available not only to insomniacs but to chronic-pain patients as well

Several years ago Dr Samuel Seltzer and his colleagues at Temple's Maxillofacial Pain Control Center began experimenting with tryptophan to see if it could raise pain resistance in normal subjects They

Tryptophan works for insomnia—and now, pain

placed 30 healthy people on a low-protein high-carbohydrate diet then gave half the subjects two grams of tryptophan a day while the other half received placebos When they probed the pain thresholds of these subjects by administering mild electric shocks to the teeth, they found that the tryptophan subjects were able to tolerate much more pain than those on placebos

Encouraged by these results in healthy patients, 'we began,' says Seltzer "to use tryptophan more forcefully in patients suffering from chronic pain ' The Temple team concentrated on 30 patients who were troubled by head and neck pain, including migraine arthritis and several types of neuralgia At the end of the first phase of the test the 15 placebo patients reported that the intensity of their pain had dropped an average of 50 percent and patients receiving three grams of tryptophan daily reported drops of up to 100 percent

Tryptophan is effective as a pain reliever Seltzer says, because it stimulates the brain's production of serotonin a neurotransmitter thought to be involved in regulation of sleep antidepressant activity and now analgesia The amino acid he adds, may one day be used to treat a wide variety of pain "It did help relieve pain in some of our arthritic patients " he says, and I think it would work for chronic back pain and other types of pain as well

—Bill Lawren

'My cat may manipulate me psychologically, but he'll never type or play the piano '

—Stephen Jay Gould

SAVE THE ONAGER

Some biblical scholars believe that when Jesus entered Jerusalem on the Palm Sunday before his crucifixion he was riding an onager, the wild donkey native to Israel's Negev Desert When King Solomon gave advice on comportment to a new bride he admonished her to be as the loving hind and the pleasant roe ' Solomon was also known to use animal metaphors in survival counseling ' Deliver yourself ' he told one subject, as a gazelle from the hand of the hunter

But in the more than 2,000 years since Jesus and Solomon walked the earth these animals—along with a number of other biblical species—have come dangerously close to extinction in Israel their numbers thinned by poaching, pollution and the denizens of civilization in general Now, thanks to an ambitious program initiated by the Israel Society for the Preservation of Nature and the Nature Reserves Authority the Holy Land is once again beginning to bloom with such ancient and honorable animals as the onager the mountain gazelle the roe and fallow deer, the wild goat and two species of wild sheep

The Nature Reserves Authority has been breeding these biblical animals in conservation centers for 20 years Now says authority spokesman Ehud Gol the group feels ready to release some of the animals to the wild In August, for instance, a small herd of onagers was released in the Ramon Crater Wilderness about 100 miles from the southern port city of Elia Although no timetable has been set Gol indicates that the release of the gazelle, roe deer and others will take place "in the near future' —Bill Lawren

Jesus entering Jerusalem on Palm Sunday 'Thy King cometh unto thee meek and sitting upon an ass ' Or perhaps an onager

CONTINUUM

The bioptic telescope: About 300 people were fitted with the lenses last year, and many have been able to drive again.

TELESCOPE GLASSES

Three years ago electrical engineer David Green, thirty-six, voluntarily gave up driving. A serious eye condition had severely limited his vision, and he no longer felt safe behind the wheel. His visual loss also cost him his job, which required enormous precision and dexterity. But now corrective glasses and an attached telescopic lens allow Green to see clearly enough to reconsider driving and to enroll in vocational rehabilitation classes.

The new device, called the bioptic telescope, offers improved vision through two sources—the telescope, which contains 14 magnifying lenses, and the corrective glasses themselves. When the wearer needs to magnify his vision just a bit, he looks through the glasses; when more magnification is required, he simply dips his head and looks through the telescope.

According to Randy Jose, of the University of Houston College of Optometry, bioptic lenses are appropriate for individuals with good peripheral vision who have trouble with details like newspaper type. Approximately 300 people nationwide were fitted with bioptic lenses last year, he adds, and many have been able to drive safely again. "Bioptic lenses allow people to read street signs at a comfortable, safe distance, picking up potholes in the road and children at play," says Jose.

Three states—New York, California, and Texas—currently issue driver's licenses to low-vision individuals wearing bioptic lenses, says Jose. In the other states, the issue is under consideration. Opponents of the bioptic telescope—manufactured by Designs for Vision, in New York City—fear that allowing these individuals to drive will increase accidents on the road. But Jose maintains, "We are talking about licensing people with usable vision to drive an automobile. That is better than ignoring these patients and running the risk of their driving without proper treatment."—Joan London

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"Neurobiology cannot be learned at the feet of a guru."

—*E. O. Wilson*

SUN AND WEED

It would surprise absolutely no one to learn that the government is the country's largest purchaser of photovoltaic cells—the silicon wonders that convert sunlight directly to electrical energy.

But according to some of the largest photovoltaic producers, the number-two group is none other than Northern California's marijuana growers.

Narc: Photovoltaics help growers avoid such individuals.

Bob Walker, who retails the cells for Arco Solar, of Los Angeles, says the great majority of his residential panels go to growers from Mendocino and Humboldt counties. He also claims that these sales account for as much as 21 percent of Arco's photovoltaic-cell output. And Herb Stachler, of Solarex, a photovoltaic manufacturer in Rockville, Maryland, agrees that Northern California buyers account for more American sales than anyone except the federal government.

Why this photovoltaic boom among the growers? The reasons are simple. Their operations can succeed only in extremely isolated environments, and no one wants Pacific Gas and Electric poking around. Gas-powered generators are expensive and noisy, and kerosene-operated appliances are expensive and smelly. So if you want all the electrical comforts of home, you want photovoltaic cells.

Most growers use their photovoltaic cells to run home appliances. But a few are using them to power irrigation systems as well. One ingenious grower, finding that his four solar panels were supplying a good deal more than the 30-odd amps per day needed to run his household, hooked his storage batteries up to his pump. "The pump would do a lot more if I had a bigger motor," the grower says, "but then it would get too noisy."—Bill Lawren

FLY DETECTIVE

Though dead men tell no tales, flies often do. That's why University of Illinois at Chicago entomologist Bernard Greenberg uses his specialized knowledge of flies and their habits to help solve murder mysteries.

"Flies are the first thing at the scene of a killing," says Greenberg. "They can detect the odor of a body up to a mile away, and the females come and lay their eggs in the corpse."

Greenberg, whose expert testimony has helped lead to ten murder convictions, usually begins his investigations when law-enforcement officials bring him flies found at the murder scene.

"There are country flies and urban flies," Greenberg explains. "If you find country flies on a body in the inner city, you can assume the body was moved."

Greenberg also studies the stage of development that the fly larvae, or maggots, have reached when found on the bodies. Cool temperatures delay fly growth, warm weather speeds it up. So by carefully checking weather reports, Greenberg calculates backwards what temperatures the flies and maggots would have needed to develop to the stage they were in when found on the murder victims. From these clues, Greenberg is often able to deduce the approximate time a crime took place.

One of Greenberg's most unusual cases involved only *photographs* of maggot-covered bodies. By studying the larvae in the photos and coupling their stage of development with weather reports, Greenberg was able to help break the three-year-old murder case by narrowing the time of the homicide to within two days. This linked two suspects to the crime, and convictions soon resulted.

Greenberg is also using flies to investigate another kind of crime. He's discovered that when hospitals neglect terminal patients on life-support systems, maggots accumulate in the slowly decaying bodies. "I've found flies actually feeding on the blood of these people," he says. "The flies lay eggs in their bodies, because they smell the odor of decay."

—Sherry Baker

Corpse at the scene of the crime. The best eyewitnesses according to an unorthodox entomologist, may be the maggots.

"Dung is no saint, but where it falls it works miracles."
—Spanish proverb

SYNTHETIC VITAMIN D

Vitamin D is made by dosing milk with radiation.

Vitamin D, also called the sunshine vitamin, occurs naturally in few foods (fish livers are an exception—remember cod-liver oil?). Thus, commercial forms of the vitamin have to be made either by "dosing" milk with ultraviolet radiation or by subjecting derivatives of cholesterol or ergot mold to the same sort of irradiation. But now a new way of synthesizing vitamin D has been developed by researchers in the United States and Japan.

The method—invented by biochemists Hector DeLuca, of the University of Wisconsin at Madison, Yoshiro Kobayashi, of the Tokyo School of Pharmacy, and Nobuo Ikekawa, of the Tokyo Institute of Technology—involves replacing hydrogen atoms with fluorine atoms at six specific sites in the vitamin D molecule. The product, known as 2627 hexafluoral calcitriol, is ten times more potent than native vitamin D.

Since vitamin D regulates the bones' uptake of calcium and phosphorus, the obvious application for DeLuca's new form is in the treatment of diseases in which this process has gone awry. Principal among these maladies is osteoporosis, a bone disease that occurs in more than 50 percent of Caucasian women over sixty. Osteoporosis causes loss of bone matter, which leads to painful back problems, easy fracturing, and even shrinkage of the body itself.

After a series of toxicity studies on animals, the next step will be to begin testing the compound on humans. At this point DeLuca believes FDA approval is about five years away. In the meantime, the drug companies are lining up. "It's just a matter of deciding who's going to get it," says DeLuca.

—Bill Lawren

CONTINUUM

INSULIN SPRAY

As many as half the 11 million diabetics in this country may benefit from a fast acting insulin nasal spray recently introduced by doctors at Beth Israel Hospital in Boston The experimental spray might eliminate the ordeal of daily insulin injections for some diabetics, the researchers say, and others could use it to augment the injection s effects

The injection may soon be replaced by the snort

The spray includes a bile salt that enables insulin to be absorbed through the nasal membranes Delivered this way the insulin begins to work within 10 or 15 minutes as compared with 60 to 90 minutes after injection

The worst complaint from the 40-odd research subjects who took part in the study was a mild stinging in the nose for up to five minutes Another possibly less irritating form is now being tested but at least three years of further refinements and clinical trials must pass before either one could become commercially available

Ideally diabetics would use the spray at mealtimes to produce normal insulin levels according to Jeffrey S Flier who developed the spray with Alan C Moses and Martin Carey

'For the majority of diabetics who are not totally insulin deficient,' Flier says 'this meal-related dose *might* suffice '

Diabetics who are tempted to try inhaling the insulin they now use the researchers caution should remember that existing forms cannot be absorbed nasally

—Dava Sobel

"The art of being wise is the art of knowing what to overlook "

—William James

HOT DECADE

You may not have noticed it, but the earth began spinning more slowly in 1970 What you *will* notice is the warmer weather that should ensue in the Nineties

This is the message of a team of French earth scientists headed by V Courtillot of the University of Paris s Institut de Physique du Globe According to their calculations the earth s rotational speed slowed abruptly in 1970, when atomic clocks indicated the day became several thousandths of a second longer

A change in spin alters the friction between the globe's surface and the air say the scientists eventually affecting atmospheric patterns The upshot? The weather will be a half a degree Celsius warmer worldwide when the next decade rolls around That means the climate of the Nineties will be more like that of the Forties 'As a child I was taken to the same place for our vacations each summer ' one of the team, J Ducruix recalls "And I distinctly remember how much hotter it used to be '

What made the earth slow down? According to the scientists magnetic fluctuations occurred deep in our planet s molten core around 1960 These in turn, exerted a force on the earth's outer mantle ten years later the fluctuations slowed the earth's spin, much as a current flowing through a magnetic coil might slow the spin of an electrical motor According to researcher J L Le Mouel his team's data provide the first solid evidence correlating weather with the earth's magnetic field —Anthony Liversidge

FLYING ORGANS

Faced with the task of swiftly delivering organs for transplants in rural Pennsylvania, a surgeon asked Civil Air Patrol (CAP) pilot Phillip Breen, "Why don t you people do something about this?"

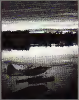
'What we did " says Breen, a physician 'is turn the state into a laboratory experiment " CAP volunteers flew organs from test centers in Pittsburgh and Danville to outlying areas keeping the program low key ' for 18 months

Those early days Breen adds, were not without drama A day after the program was approved a pilot carrying a living kidney

Look for warmer weather in the Nineties Thanks to magnetic fluctuations deep in the earth's core the planet is slowing down

lost her radio en route to Philadelphia. The airport used a light gun, a landing aid that predates radio, to bring her in.

Eventually the group began providing statewide service and finally developed a national program. "Lists of available pilots and their locations are fed into a computer in Richmond, Virginia," Breen explains. The computer matches



[illegible] planes are solving the [illegible] problem

[illegible] to the nearest pilot.

"The [illegible] is intended to supplement, not replace, commercial deliveries," Breen says. "Since the CAP [illegible] military organization, we're used to sitting and waiting," he adds. More seriously, he notes that a volunteer pilot can be ready to go when given the word. "Commercial airlines can't do that."

—Allan Maurer

We are all agreed that your theory is crazy. The question which divides us is whether it is crazy enough.

—Niels Bohr

POTATO POWER

When his stepdaughter Heather needed an idea for her sixth-grade science-fair project, North Carolina electronics technician Bill Borst recalled an experiment in which his high school physics teacher generated electricity from an ordinary potato. So Borst helped Heather build a small digital-display clock that ran on spud power.

Unfazed when Heather's teacher rejected the timepiece as inappropriate for the science fair, Borst refined his clock—crafting a clear Plexiglas case for it—and he now hopes to find a company to mass-produce it.

Simply put, Borst's clock is powered by what might be described as an organic battery. It runs on two potatoes—each impaled on a pair of metal bolts that are wired to the digital display mechanism of the clock. One bolt of each pair is copper, and the other is zinc. These dissimilar metals react with acid in the potato, causing a chemical reaction that generates electricity. "I get 0.85 volt from each potato," Borst says, "and the clock needs 1.5 volts to operate."

Spud power is very economical, but Borst notes that the potatoes go dead in just four weeks. The clock works with apples, oranges, lemons, tomatoes and onions (to name a few), Borst says, but potatoes stay fresh longer at room temperature.

—Eric Mishara

PYRAMID LIGHTING

It all started 4,000 years ago, when the pyramids were under construction. In order to light the interior without smoky torches and lamps, polished bronze shields were aligned to reflect daylight deep into the recesses of the tombs. Now a researcher wants to borrow that idea to light the interior of residential and high-rise buildings, cutting energy consumption by as much as 80 percent.

Daylight penetrates up to only 25 feet into a building, explains engineer Claude Robbins of Denver's Solar Energy Research Institute. Lighting the rest of the floor space produces so much heat that air conditioners must be used to cool skyscrapers even in winter. Thus, finding a way to bring daylight deeper into a building, as the ancient Egyptians did, could be a way to save billions of dollars in energy costs.

To accomplish this goal, Robbins placed two mirrors—dubbed heliostats—on the roof of a building: one was movable and followed the sun's path across the sky, and the other was fixed. The moving mirror reflected sunlight onto the fixed mirror. The fixed mirror then shot a beam of light down a shaft that passed through each floor. Each 15-square-foot polished aluminum mirror can light up 1,500 square feet of floor space, and using several mirrors increases the intensity of the light as well as the area lighted.

Robbins says heliostats are about to be installed on an Arizona home and a two-story building in Kansas. He hopes they will soon be common fare in skyscrapers, hospitals, schools and retail stores as well.—Ben Barber

The builders of the pyramids developed a [illegible] that could cut high-rise energy consumption [illegible] 80 perc[illegible]

CONTINUUM

TIMELESS MINDS

"When I wake you the past will be gone," Dr Bernard Aaronson, of the New Jersey Neuropsychiatric Institute, told a deeply hypnotized college student

No past equals no meaning, no future equals no identity

When the posthypnotic suggestion took hold the student became drowsy and infantile, losing both memory and the powers of speech Later he reported a vague sense of meaninglessness

The young man without a past was one of ten college students who took part in an unusual experiment with psychological time warp Aaronson gave some subjects posthypnotic suggestions that eliminated their past present, or future, he gave others a vastly expanded past, present, or future The consequences were profound

With no future, people felt a loss of identity and a euphoric, mystical sensation free of both anxiety and motivation One student found himself in a "boundless immanent present" Expanding the future, on the other hand canceled all fear of death and induced serenity contemplation, and a feeling of self-fulfillment

Being robbed of a past brought on a semi-infantile torpid state, and students with a dilated past became egocentric and inhibited

Canceling the present was the most disturbing, however One subject turned catatonic, others became severely depressed and almost schizophrenic Stopping subjective time altogether produced an eerie sensation of death "The world moves on, but I don't," one student observed

Aaronson's conclusion Life must carry some sense of direction, from past to present or present to future to seem worth living People given a present shorn of a past and future become preoccupied with death and behave like schizophrenics This finding together with the high suicide rate among schizophrenics, he notes "raises the question of whether schizophrenia may not be a psychic analogue to dying"

—Robert A Freitas, Jr

"It is the dull man who is always sure, and the sure man who is always dull"
—H L Mencken

BACTERIA ON VENUS?

Life may be possible on Venus and other hot planets, say two oceanographers who recently found a strain of deep-sea bacteria that can thrive and multiply at temperatures of 250°C (That's 150° above the boiling point of water and 17° hotter than the temperature at which paper bursts into flame)

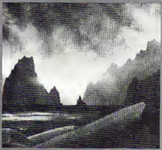
John Baross of Oregon State University, and Jody Deming, of Johns Hopkins University's Chesapeake Bay Institute used a laboratory pressure cooker to heat up the bugs, which could exist—though they could not reproduce—even at 300°C The hot bugs' normal habitat is some 1 65 miles beneath the surface of the Pacific Ocean the scientists explain Thus, the experiments show that bacteria growth is "limited not by temperature but by the existence of water"

The scientists add that only a handful of bacteria can withstand temperatures above 70°C, and that most plants and animals die if their temperatures exceed 40°C Nonetheless, the researchers say, their experiment indicates that "there are a large number of environments, both on Earth and elsewhere where life can exist"

—Tom R Kovach

"Not to go on all fours That is the law Are we not men?"
—H G Wells

"The frontiers are not east or west, north or south but wherever a man fronts a fact"
—Henry D Thoreau



Welcome to the surface of Venus where it's so hot, life is impossible except perhaps for a newly discovered strain of bacteria

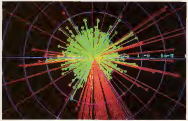
Beneath the placid prairie, atomic particles are smashed into fragments from the birth of the universe

QUARK CITY

BY RICHARD WOLKOMIR

"Simplify, simplify."

That dictum from writer Henry David Thoreau has become a holy quest for today's physicists. No Walden Pond cabins for them, however—they seek nothing less than to simplify the entire cosmos. As Leon Lederman, director of the Fermi National Accelerator Laboratory (FermiLab) in Batavia, Illinois, puts it: "We hope to explain the entire universe in a single, simple formula that you can wear on your T-shirt."



One short equation would sum up creation—the Milky Way, black holes, quasars, pulsars, nebulae, bullfrogs, and grandpa's mustache. It would enchant the planet's 500 top scientific minds with its elegance, mystify the rest of us, and rearrange the world even more than $E = mc^2$ did. Ironically, though, in pursuit of this ultimate simplicity physicists are building the largest, most complex machines ever conceived—enormous particle accelerators. These astonishing instruments focus back through time almost all the way to the instant of creation in the Big Bang. And they reveal not just the particles making up atoms but the particles making up the particles.

Right now physicists are planning a behemoth, an accelerator 100 miles around, called the Superconducting Super Collider (SSC). It is nicknamed "Desertron," since only a desert has room for it. At least, so argue Texans avid to host the multibillion dollar machine. FermiLab, equally eager at its grasslands site near Chicago, prefers another nickname: "Prairietron." And Brookhaven National Laboratory hopes, somehow, to squeeze the giant SSC into its central Long Island acreage.

The Great Pyramid of Cheops was a sand castle compared to the proposed SSC. Even the current heavyweight accelerator champ, FermiLab's new Tevatron, is larger and more blindingly complex than any machine ever built. Physicists believe the Tevatron will open enough new territory for exploration to keep them occupied a decade or so, until the SSC comes on line. And U.S. physicists are counting on the Tevatron to switch the scene of scientific action from Switzerland to Illinois.

"With many discoveries in this field emanating recently from CERN [Centre Europeen pour la Recherche Nucleaire], the Western European laboratory near Geneva, the FermiLab Tevatron is expected to begin to redress the balance in the cooperative rivalry between the United States and Europe." That's what Lederman said on July 3, 1983, when he announced that, in its maiden voyage that afternoon, the new machine had achieved record power: 512 billion electron volts (eV) in one beam. Yet that is just a fraction of the Tevatron's ultimate potency. Eventually inside the Tevatron two beams of particles will smash into each other with a total force of 2 *trillion* electron volts (2 TeV, the root of Tevatron's name).

An electron volt, the energy an electron picks up traversing a one-volt electric field, about the energy in one flashlight battery, is the basic horsepower unit for accelerators. The escalation of accelerator voltages over the decades has enabled physicists to probe ever deeper into matter. As Lederman points out, "Before you give too much credit to the theorists, you should know that the history of particle physics is really a history of inventions."

Lederman likes to trace atomic physics to Classical

PHOTOGRAPHS BY DAN McCOY

"Zipping around this huge ring, the protons are focused by magnets into a tight beam the size of a straw"

Greece's Empedocles, who believed the world was made of four basic substances (earth, air, fire and water) and two forces (love and strife). The first particle accelerator, he says, was designed by Galileo Galilei. The Italian inventor dropped objects from the leaning tower of Pisa, causing them to accelerate with an energy equal to about one ten thousandth of an electron volt. But the first modern accelerator was the cyclotron, invented in 1932. Its "horsepower" was a few million electron volts. In the Fifties, Brookhaven National Laboratory built the Cosmotron, which reached 3 billion electron volts, abbreviated either as 3 BeV or 3 GeV (*G* stands for giga, or one billion). Next came the University of California at Berkeley's Bevatron, which attained 6.2 GeV. In 1973, under an Illinois cornfield, FermiLab built a 400-GeV machine. For a time the big FermiLab accelerator and new machines at such physics research centers as Brookhaven National Laboratory, Stanford Linear Accelerator Center, and Cornell University made U.S. physicists the princes of the particle world.

But since 1978 the balance of power has shifted, with Europeans funding particle physics at twice the U.S. rate. Top U.S. physicists have gravitated to Europe's CERN laboratory, where beams of protons and antiprotons collide with a combined energy of 540 GeV.

With U.S. physics looking limp, physicists have worried that bright science students, denied world-class accelerators, would opt for other fields, drying up serious physics in this country. As Harvard University Nobelist Sheldon Glashow puts it: "The United States has been completely outclassed by our European rivals."

But the gloom has lifted. Across the country plans are suddenly afoot for a variety of souped-up, new accelerators. FermiLab's Tevatron, inaugurated just in time for the Fourth of July, 1983, is now the world's most powerful unit, opening unexplored territory. And Tevatron is a technological breakthrough that will make pos-

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Preceding page: FermiLab's main building overlooks 6,000-acre site. Inset shows one screen of a complex computer system monitoring superconducting magnets. This page, left: Worker stands in tunnel that houses accelerator rings hidden beneath Illinois grasslands. Above: White caps protect stored magnets from dust.

sible new generations of even more powerful atom-smashing machines

FermiLab is surreal, a 6,000-acre swath of open plain among the suburbs 30 miles west of Chicago. Rising from its center is a 16-story skyscraper, the central laboratory. Its core a sunlit atrium, bushy with trees. Fermilab's strong-willed founding director, physicist Robert Wilson, oversaw the skyscraper's design. Insisting on total control of all the laboratory's architecture, he had buildings painted bright blue, yellow, or orange. One is roofed with sections of steel culvert, another with what seems a huge, multifaceted crystal. Wilson designed the steel sculpture arching over FermiLab's entrance. And he even redesigned power-line towers, shaping them like the Greek letter pi because he liked the way the letter looked.

But FermiLab's heart is 20 feet below the prairie, a doughnut-shaped tunnel that's four miles in circumference. Above the ground, the tunnel is invisible except for a low mound tracing its route. Nearby in a prairie-reclamation project, bison graze on grasses taller than a basketball player. Only one indicator reveals the intense forces streaming through the tunnel below. In the winter the central tower's surrounding ponds and the moat circling the tunnel's route steam like Yellowstone's hot springs, dispersing the accelerator's heat. Year-round the heated water is home to squawking flocks of mallards, Canada geese and trumpeter swans, an ecology situated above protons and antiprotons shooting a kind of high-energy rapids.

"Tevatron is a cascade system, like a series of waterfalls," says FermiLab accelerator division's Timothy Toohig, a physicist who is also a Jesuit priest. Five separate accelerators, hooked together, each more powerful than the last, form the Tevatron. It is the task of each of the first four accelerators to rev up the particles for the next stage, finally feeding them into the fifth accelerator, the new Tevatron ring itself. This ring is a thoroughbred that, in seconds, takes protons from 150 GeV to 1 TeV. In this final stage the particles scream around the ring at the speed of light. Then they end their careers in a grand smash, obligingly spraying out their innards for the inspection of physicists. In this cascade each step recapitulates a portion of the history of particle accelerators, from the oldest to the newest.

Accelerator one in the series, a Cockcroft-Walton generator, evokes the era of its invention. It is a room-size chunk of pure Art Deco, all shiny metal and rounded edges, like a prop for a Thirties Buck Rogers movie. But the machine's rounded edges are functional, deflecting lightning bolts that build up inside, where the generator attaches two electrons to protons extracted from hydrogen nuclei. Accelerators downstream can handle these ions better than naked protons. By using an electric field, the generator accelerates these tiny threesomes to 750,000 electron volts (750 KeV).

Now warmed up, the ions stream into the second stage in the cascade, a linear accelerator, or linac. A two-mile-long linac in California, the Stanford Linear Accelerator (SLAC), revs up particles to 30 GeV. But FermiLab's linac is only 500 feet long, merely the second step in the Tevatron cascade. Inside, hundreds of copper electrodes generate oscillating electric fields—if visible, they would resemble waves of surf. Like tiny surfers, the ions hitting these waves receive a forward kick along a straight-line course. At the linac's exit, the charged particles have reached 200 million electron volts (200 MeV).

Next the ions shoot into the circular, 500-foot-diameter booster accelerator, which strips away their electrons, no longer an aid to acceleration, leaving only the protons. The booster is a synchrotron designed to finesse a linear accelerator's major weakness. Like a straight drag-race strip, it accommodates only limited speeds.

In a synchrotron particles zoom around a circular tube like cars in the Indianapolis 500. Particles guided by electromagnets race at nearly the speed of light. Radarlike radio-frequency generators (called RF cavities) give the passing particles their accelerating kick. But that increases their mass, an effect Einstein predicted in his theory of relativity. To compensate, the electromagnets increase their power as the particles' masses increase, a process called ramping. With every crossing of the RF cavities, the orbiting particles gain more energy. Finally, they leave the booster at 8 GeV and enter a much larger synchrotron, the main ring.

Before Tevatron, the main ring, four miles in circumference, was the protons' last mad sprint before the final smash. Zipping around this huge ring 50,000 times per second, held on course by 1,000 electromagnets, and focused into a tight beam the size of a soda straw, the protons absorbed a 3-MeV kick every time they passed the RF cavities, attaining a final energy level of 400 GeV. That gave FermiLab the horsepower edge in what Lederman calls international physics collaborative rivalry. Two troublesome worms appeared in the apple, however: the energy crisis and CERN.

"When the energy crisis hit, we were suddenly paying eight-million-dollar electric bills, though we were operating just twenty-two weeks a year, which was all we could afford," says Toohig.

Meanwhile, CERN was building far superior equipment and planning to modify its 400-GeV machine into a new accelerator in which particles would collide with 540 GeV total energy. Facing this formidable international competition, Robert Wilson, then FermiLab's director, decided to build a new machine that would be cheap to operate yet more potent than CERN's. For this giant, which was to be

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"Yes, but what do you think? Yes, but what do you think? Yes but what do you think? Yes, but what do you—"

GUINEA PIGS

Octopuses, armadillos, and other strange critters may provide the future's biggest breakthroughs

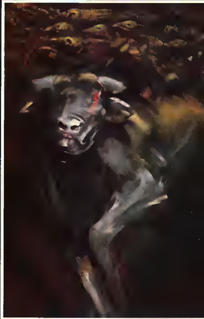
BY FRANK KENDIG AND LISA BUCK

PAINTINGS BY MARSHALL ARISMAN

Here in the United States, where some 220 million humans and nearly 400 million chickens reside, we own about 1 billion animals. We fry some, fondle others. And about 5 percent—estimates vary from 40 million to 75 million—we keep in laboratories, despite the strident protests of animal-welfare groups.

Over the last decade and a half, the population of laboratory animals has been in sharp decline, for reasons more economic than humane (it is very expensive to keep an animal in a lab). But within this shrinking population, there is one small subgroup that has been growing in numbers. For the most part these are exotic creatures, at least in the laboratory world. Some are studied for their special abilities to thrive in hostile environments. From them we may learn how to survive in space or in the depths of the oceans. Others share our vulnerability to certain diseases and serve as valuable models to study those ailments. A few are so unlike us that they suggest unique, often astonishing solutions to some of our more persistent medical problems. They are not a particularly cuddlesome lot, and nobody pickets to defend their rights. They are the unsung heroes of research.

Our scientific relationship with animals began to blossom in 1798, with the cow. Edward Jenner, a physician in Gloucester, England, noticed that local milkmaids developed a poxlike rash on their



hands from milking, but did not contract smallpox Jenner began to innoculate humans with the cowpox virus; that same vaccine with only slight modification is still in use today Because of it, smallpox has been virtually eliminated from the planet.

Typical research animals today are most likely to be rats or mice—creatures that are relatively inexpensive to use and can be bred for specific research needs To a lesser degree, monkeys have been used because of their humanoid characteristics But forget about rodents and monkeys for a moment Consider the nine-banded armadillo Kipling described it as half-hedgehog, half-turtle Audubon called it a little pig wearing a saddle Cortez gave it its official name—armadillo, the little armored one This odd-looking, toothless mammal, often seen browsing along the median strips of Western highways, has a number of features that make it uniquely attractive as a research animal First of all the female has a remarkable reproductive tract in which its fertilized egg divides twice after conception. The result is a set of identical quadruplets, every time The advantages for genetic research are obvious

The armadillo also has a particularly low body temperature for a large mammal, a feature that has led to its use in the study of leprosy "Leprosy attacks the cooler parts of the human body, such as the ears and nose," says Eleanor Storrs a biologist at the Florida Institute of Technology in Melbourne and the first to consider the armadillo as a research animal for leprosy "I knew that armadillo body temperatures range from twenty eight to thirty-three degrees Celsius compared with thirty-seven degrees for humans So I began to see a possible connection " This was an especially important discovery because at the moment there are only two animal models for leprosy humans and armadillos In the armadillo the disease progresses quickly Symptoms develop as early as six months after exposure to the leprosy bacterium (In humans the period can take as long as six years) Since armadillos live well into their teens the disease can be tracked over more than a decade in a particular animal

Researchers also like to work with animals that inhabit hostile environments The Egyptian sand rat for example makes its home on the edge of the Dead Sea in Israel where the soil and, consequently, the plant life have a high salt concentration The animal's kidneys are so efficient that the sand rat can safely drink water that is four times as salty as seawater

In spite of their ability to thrive in the desert many of the rats could not at first survive in the lab of Jerusalem's Hadassah Hospital They developed diabetes and died The reason improved diet The researchers had supplemented the rats' usual food with vitamins protein and trace minerals, and the animals, accustomed to "poor" diets, developed diabetes Once their diets were returned to normal, the sand rats flourished.

This on/off type of diabetes may help the sand rat survive in the feast-or-famine world of the desert When the animal finds food, its blood-sugar level rises dramatically and remains high, says Harvey Pollard of the Laboratory of Experimental Pathology at the National Institute of Arthritis Diabetes and Digestive and Kidney Disease The high levels may serve to sustain the animal in lean times Among humans, some American Indians, such as the Pimas of the southwestern United States develop a similar type of diabetes characterized by obesity, high blood sugar, and high insulin levels. So it might be that diabetes as a genetic trait offers significant survival value to a population, human or otherwise, with an inadequate or erratic food supply

Turtles have become popular research animals because of the intriguing way they have of dealing with cold During the winter months, many turtles simply dive to the bottom of a lake or pond, hold their breath and remain there without coming up for air until the weather warms They get the oxygen they need by exchanging gases through their skins while lying quietly on the bottom.

"There's been a lot of interest in turtles among surgeons and anesthesiologists because, during bypass surgery, the temperature of the patient is brought way down while the anesthesiologist controls the patient's breathing " says physiologist Donald Jackson of the department of biology and medicine at Brown University in Providence Rhode Island "It may turn out to be a good idea to try to mimic what happens in the turtle to control the patient's breathing "

Two other animals not usually associated with the laboratory the opossum and the seal, are now part of experiments that may provide us with vital information for survival in space In fact the Virginia opossum the only marsupial indigenous to the United States seems a likely candidate for a trip into space all by itself Unlike man and the other eutherian mammals (those whose young are born fully developed) marsupial babies complete most of their development outside the uterus They leave the uterus at a stage of development equivalent to that of a two-month human fetus and from that point on their main maternal contact entails little more than getting milk from the mother

William Jurgelski medical officer at the Office of Health Hazard Assessment at the National Institutes of Health (NIH) and one of the world's leading experts on marsupials has proposed sending newborn marsupials such as opossums into orbit as a prelude to the first human birth in space Jurgelski notes that little is known about the effects of weightlessness on growth and development, especially at the critical early stages of life Neonatal marsupials attached to special marsupial life support systems (which Jurgelski has already designed and suggested to NASA) would allow studies of the effects of microgravity on growth and development

That opossum newborns undergo most of their development outside the uterus also makes them valuable for studying childhood diseases The opossum is the only experimental animal able to develop a number of tumors found in human infants "We can chemically induce cancers in young opossums without harming the mothers " says Jurgelski "So this animal provides an excellent way to study the development of childhood cancers " It is also the only laboratory animal that spontaneously develops bacterial endocarditis, an infection of the heart muscle

Opossums have another characteristic, an uncanny ability to get loose Jurgelski recalls the time he was keeping opossums at a hospital laboratory "One night around three A.M. a nurse in one of the wards heard a plop and turned to see an opossum behind her Apparently it had gotten out of its cage and traveled through the air ducts She got hysterical and called the police who captured it People think these animals are stupid but they will escape from anything that isn't absolutely foolproof "

If opossums might tell us something about growing up in space seals particularly the Northern fur seal may provide important clues to other problems of weightlessness These seals spend most of their life in the ocean and do not come ashore except for the short summer mating season Says Mark Keyes, veterinary medical officer at the National Marine Mammal Laboratory in Seattle "To change suddenly from a semiweightless condition in the ocean to supporting such a heavy body on land is a transition comparable to that of an astronaut returning to Earth from outer space " For that reason he thinks the seal is a good animal model for the effects of weightlessness and space travel

Keyes thinks the Northern fur seal will also be valuable for studying the effects of decompression sickness in deep sea divers Working with Merrill Spencer he has used special instruments to monitor the heart and lung adjustments that a fur seal makes when diving During experiments at the Virginia Mason Research Center in Seattle, Keyes adapted this equipment for humans with a device called a topical flow meter It emits sound waves that can indicate concentrations of nitrogen bubbles in the blood before the symptoms of decompression sickness are apparent to the divers themselves

Keyes was the first to notice that the

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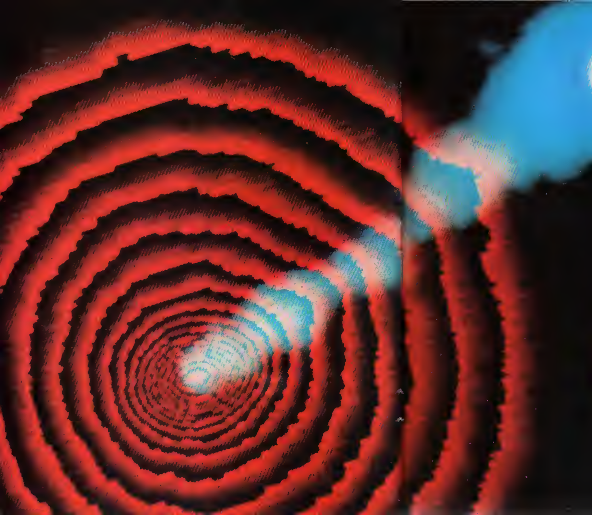
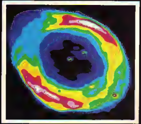


Outfit a telescope with a silicon chip, press hyperdrive, and the intergalactic tour begins

ASTROVIDEO

BY RICHARD WOLKOMIR



PHOTOGRAPHS BY TOM STEPHENSON

On a screen in a darkened room at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts a million blue and red stars coalesce into a spiral galaxy. The swirl of stars turns iridescent green, then tan. It seems to harden. Then it simplifies into a map—orange, maroon, and brown. Up one side a column of pink digits materializes.

"I look out as far as possible, at ancient galaxies," astronomer Rudy Schild tells a visitor as Schild presses more buttons on what looks like the control console of the *Millennium Falcon* from the Star Wars trilogy. He is surrounded by banks of screens showing star fields and digital readouts. With his motorcycle boots and Jesus-style beard, Schild looks just right as space skipper for a voyage to galaxies long ago and far away. But this is no movie set. The image processor he is piloting is a key system in the new electronic astronomy which astronomers say is revolutionizing the way they study the cosmos. "Look at this galactic cluster," Schild says in his pulsar-burst fashion, blue eyes intent behind glasses. "Here we're looking back very close to when the universe was created."

Up on the biggest of the control panel's six screens swims a whirlpool of lights: ruby in the center, the swirling out-flung arms bright blue. Schild punches a button, and the screen fills with a new image. A turquoise halo of intergalactic dust hangs in black space. "That's a ring nebula," he says. "Now let me show you some of the outrageous things that we can do with image processing." He presses buttons, and the nebula changes from turquoise to bright white, shot with red and yellow.

"I just encoded the image for light intensity, with those white sections the brightest and the dark reds the lowest," he says. More buttons. "Here's another galaxy."

A tuzzy red cherry materializes on the screen. It's a galaxy roughly elliptical in shape. Schild shoots a yellow line across its center. "What I'm doing is taking a slice through the galaxy, and I'm going to have the machine graph the luminosity levels along that slice from one side of the galaxy to the other," he says. Across the galaxy's image snakes a white horizontal line, sinking to a trough where the galaxy shines the dimmest, rising to a peak where it is brightest. Another screen fills with numbers: digital readouts of the brightness levels at each point along the graph line.

"Now we'll do this," says Schild, transforming the galaxy into a mud splat on yellow sand. It hardens into a cartoon drawing of concentric circles, like a contour map. The area within each ring represents a different level of brightness. "That's another way of plotting the galaxy's structure, just one more thing we can do with image processing. We couldn't do any of this with old-fashioned film astronomy."

Five thousand years ago, when the astronomers of Sumer gazed at the night skies from the tops of ziggurats, their instruments were their eyes, which see only a narrow swath of the electromagnetic spectrum: wavelengths from red to violet. Standing atop their mud-brick towers and gazing at the constellations, the Sumerian wise men saw none of the ultraviolet and infrared light streaming down. Nor were they aware of the X rays, gamma rays, and radio waves radiating from the stars. Even in the visible-light ranges, most stars were too faint for their eyes, processing light with an efficiency of less than 3 percent.

Then, in the seventeenth century, came astronomy's first revolution. Looking through a new instrument, the telescope, Galileo exclaimed that the stars were "so numerous as to be beyond belief." English

"Equip an ordinary telescope with a video chip, and it will outperform the giant reflector at Mount Palomar. Projects that took weeks now take hours with electronics."

researcher Thomas Wedgwood's invention of modern photography in 1802 was astronomy's second revolution. By the late nineteenth century, photographic plates attached to telescopes were outperforming eyes. With long exposures they could gather more and more light, seeing objects too faint for the unaided eye looking through the telescope. Also, astronomers could store their plates for later study. Eventually chemists produced photographic emulsions sensitive to infrared and ultraviolet, and began to measure a star's or galaxy's brightness scientifically, instead of just guessing.

So much for that archetype of scientific folklore: the night watcher squinting at Betelgeuse through an observatory telescope. For many decades astronomers barely glanced at the actual skies. Instead they scrutinized chemical films darkened by light twinkling in from far away. Like Roman augurs seeking omens in the cracks of roasted bones, they sought interstellar news by studying chemical grains on photographic plates. But now photography is giving way to a more powerful technology: light-sensitive chips.

"I haven't used photography scientifically in at least six years," says David Latham, associate director for optical and infrared astronomy at the Harvard-Smithsonian Center for Astrophysics, where the revolution is well advanced.

Photography's last stronghold, Latham notes, is surveying vast areas of the sky in what amounts to stellar nose counts. That is because a photographic plate can be as large as you wish. On the other hand, the new technology's basic device, a silicon chip, is about the size of the fingernail on an infant's pinkie, with that square centimeter of electronic sensitivity costing perhaps $5,000. Yet for most astronomical work, the chips have all the advantages.

"For one thing, you can use a photographic plate only once, but you can use a silicon chip over and over," says Latham.

More important, he adds, chips collect data in a digitized format. Thus a chip's information can feed directly into the other main components of electronic astronomy: computers and image processors. Chips are also far more sensitive to light than are photographic plates. That means astronomers can now look farther into the universe than ever before and they can squeeze more meaning from the data they retrieve, all thanks to tiny electronic circuitry.

The electronic revolution actually began back in the late Forties, when astronomers began to soup up their telescopes with photomultiplier tubes, a kind of electric-eye device. Photons of distant starlight streaming down the telescope hit a photoelectric surface in the photomultiplier tube, and the surface reacted by emitting electrons. The photomultiplier then amplified these spurts of electrons thousands of times, into a readable electric current. By measuring the current, astronomers could accurately measure the brightness of starlight.

With efficiencies of about 20 percent, the tubes easily outsaw photographic plates. But their target area was small, just one star. To analyze an entire galaxy, the astronomer had to study it section by section, running up big bills for telescope time. Thus, by the Eighties, when silicon video chips began to take over, astronomers welcomed the new technology.

"Most of the science here at the center is now done with electronics," says Latham. "Ultimately, I suspect, electronics will completely take over."

Behind the electronic revolution is the charge-coupled device (CCD)—an array of chips about the size of a postage stamp. Mounted at the telescope's focus, the CCD acts as a miniature television camera. When photons of light—perhaps from a distant galaxy—strike the surface of the chips, the silicon crystals respond by emitting electrons. The movements of these electrons make the CCD an effective watcher of stars and galaxies.

Each chip within the array is checkerboarded into hundreds of sections of low electric potential, called wells, which attract the emitted electrons. Other zones of

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Previous page: The bright elliptical galaxy M87 (red contours in larger photo) issuing a blue gas jet. Smaller photo shows the Ring Nebula, a halo of gas in our own Milky Way Galaxy. Light-sensitive silicon chips feeding a computer were used to produce both of these images. Photos courtesy of the Harvard-Smithsonian Center for Astrophysics Image Processing Facility.

Field and forest, earth and air are living subjects of a vegetal kingdom

WILD BOTANICAL FANTASIES

BY LEAH WALLACH

"You look at a jungle in my paintings," Wolfgang Hutter says, "and the jungle looks back at you." The Viennese artist makes crazy botanical quilts that are at once landscapes and eerie group portraits. Clouds of cloth, spheres of wind, waves of tendrils, tumescent flowers, and leaves fanning out in blades, curling in arabesques, and unfolding like hands all crowd together on his canvases, each vegetal surface forming its own plane. There are no shadows. There is no source of light. The surfaces of his paintings are sleek, the edges of each botanical membrane sharp, the colors vivid, the curves so exact that they seem measured. "Very precisely painted," Hutter says of them. "Very beautiful and full of fantasy. They are

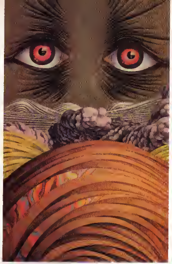
Below: Blatteraugen *(Eyes of the Leaves) depicts an eerie botanical vision amid the foliage. Right: In* Vegetabiler Kopfschmuck *(Vegetal Headdress) the artist suggests a personality resides within the petals.*

landscapes where no humans have ever traveled."

They are also full of presences. Hutter's flora has eyes. "In my paintings, you can see lots of plants," Hutter explains. "The plants become human beings who can watch and move. Eyes are very important."

Hutter was born in Vienna in 1928 and has lived there ever since. Along with Rudolf Hausner, Erich Brauer, and Ernst Fuchs, Hutter was one of the so-called fantastic realists, a group formed at the Vienna Academy of Art in 1948. While everyone else was painting abstractly, the four artists were staking new territory by figuratively depicting inner worlds. Today

Upper left: Ein Kuss *(The Kiss), a romantic interlude. Lower left:* Der Suchende *(The Seeker), in which Papageno searches for Papagena in Mozart's opera* The Magic Flute. *Right:* Die Doppelaugen *(Double Eyes).*



the individual styles of the four are quite distinct. But their work recalls to varying degrees the fairy-tale graphics of art nouveau, the sensuality of primitivism, and the emotional intensity of expressionism. Albert Paris Gutersloh is considered the spiritual father of the movement. In 1944, when Hutter was sixteen, his mother told him some startling news—that Gutersloh was his *real* father as well. But Hutter's comment about this major Oedipal discovery is spare. "I was amused," he says.

Hutter is less inclined than some of his fellow fantastic realists to talk of subconscious symbolism and metaphysical mysteries. His eyes are not symbols but eyes. He paints pictures of invented places where field and forest, earth and air are not only alive but also sentient. For some viewers, the fantasy is fearful. The wide-open eyes, irises riveted in a great expanse of eyeball, seem trapped in the vegetation. But to Hutter the peering plants are beings of magical, not to mention erotic, charm. "They're my own plants," he says, "and I love them." ◘◘

Left: Detail from Flug durch die kunstliche Landschaft *(Flight Through an Artificial Landscape). Above:* Der Graue Augenhimmel *(The Gray Eyed Sky), a haunting, vegetative observation from the clouds.*

"His eyes are not symbols but simply eyes"

"You're wasting your time,"
this mathematician was told by his
peers, until his
monstrous, bizarre fractals, with their
strange dimensions,
began taking over the world

INTERVIEW

BENOIT B. MANDELBROT

As his first task as a staff mathematician at IBM in 1958, Benoit B. Mandelbrot was asked to address the intractable problem of "noise in the system," the random irregularities intrinsic in signal transmission. The first thing he did was tell his colleagues to forget about the noise.

"But we have an explanation for it. It's guys working with screwdrivers somewhere in the network," they replied.

"I don't want to hear about theories now," Mandelbrot responded. "There are always guys with screwdrivers; we'll never know their schedules. Besides, how could men with screwdrivers generate chaos with that kind of systematic structure?"

Mandelbrot realized that noise was, in fact, deeply embedded in nature and impossible to drive out. Thus, he doomed many burgeoning attempts to predict, suppress, or eliminate it. The noise issue was an early example of the strange logic of *fractals*—the unruly collection of irregular geometric phenomena that only Mandelbrot seemed to comprehend at the time. He won his case, however, and was instrumental in halting a multimillion-dollar research project that would have gotten IBM nowhere. "Whether IBM understood the problem or not," he now says, "they couldn't change it, and the technology they were trying to build around it couldn't possibly work."

Noise, with all of its weird manifestations, contributed to Mandelbrot's mighty inspiration—the genesis of fractal geometry. From problem solving in electronics and economics, from long-ignored corners of geometry and probability theory, and from a passionate conviction that there is order in the most random and irregular phenomena, Mandelbrot created a new world of thought. Twenty-five years ago fractals—not yet named by him—were his private obsession. Today they are standard tools in

PHOTOGRAPH BY MALCOLM KIRK

some branches of science, exciting new approaches in many more. As the "father of fractals," Mandelbrot has engendered strange new dimensions. He has established fractals' scale and direction and proved their relevance to the real world when others had dismissed them as uselessly abstract or—worse—as pathological monstrosities.

Born in Warsaw in 1924, Mandelbrot and his family moved to France in 1935. His early mathematical education was irregular, much of it based on outdated classics of the nineteenth and early twentieth century. Even at a young age his methods were as unusual as his preparation. In the rigorous examinations at Paris's Ecole Polytechnique he repeatedly solved problems by geometric approaches instead of the prescribed analysis.

At Caltech, where he studied aeronautics, Mandelbrot encountered the daunting complexity of turbulence—the wildly tangled fluid motions that, above a critical speed, replace streamlined flow. Today fractals are central to two of the three main approaches to turbulence, permitting precise descriptions of shapes that seemed utterly chaotic a few years ago. (Mandelbrot's extraordinary designs are displayed in "The Fractal Cosmos," in the February 1983 issue of *Omni*.)

Why was it necessary to conceive and develop a new geometry of nature? Until recently all the curves and surfaces presented to schoolchildren and used by scientists in their theories of nature were smooth. Such shapes can bend, but they must bend gently. If such a smooth curve is sufficiently magnified, it looks more and more like a straight line. For example, the spherical surface of the earth looks almost flat on some scales, and the illusion of flatness is good enough to cause some controversy even today. In other words, the traditional smooth curves all look alike from some perspectives. And the features that make them differ are apparent only on certain scales of measurement.

This is too bad if you want to understand nature, because many of her faces possess structure on a very wide range of scales. Consider the bark of a tree. On the usual human scale, it looks rough. If it is magnified, it *still* looks rough. The larger-scale crinkles are themselves crinkled on a smaller scale, and there is a whole hierarchy of subcrinkles and sub-subcrinkles, right down to something close to the molecular level.

Or consider a stretch of coastline. What appears on a map to be a smooth, curving bay does not look smooth close up. Even at high magnification a coastline's shape is crinkly and irregular. Mountain landscapes, the craters on the moon, the fine structure of Saturn's rings, the folded surface of the lung—all of these possess structure on a great many scales. It follows that the traditional smooth curves and surfaces of science proved inadequate as models of these features of nature. A different geometry of nature was needed, but none was available.

At about the turn of the century a few mathematicians had come to study such "infinitely crinkled" curves as the "snowflake" curve. This creation of geometer Helge von Koch is a triangle with smaller triangles stuck on its sides and yet smaller triangles stuck to these new sides until every small piece of the curve is infinitely "prickly." What motivated these mathematicians? By no means had they set out to study the bark of trees, the coastlines of islands, or the lining of the lung. They thought they were fleeing from nature and that the sole function of their contraptions was to prove the creative power of the most abstract mathematics. As a result these curves were called pathological, both by their creators and by everyone else.

It is only in the last decade or so that it has been widely recognized that, to the contrary, suitable curves of these types should be considered natural and can be used as models of natural processes. This recognition is largely due to the work of Mandelbrot, who coined the term *fractal* to describe such curves, created new fractals, and energetically pursued them at a time when it was not fashionable to do so.

"I identified the particular feature of reality that makes the stock-market charts look the way they do. By changing a number, my model could fake charts of high or low volatility."

A fractal curve can be viewed as an intermediary between a traditional curve and a traditional surface. A curve is one dimensional, a surface is two dimensional. The fractal dimension of a fractal curve is a number that lies in between. It can be 1.5 dimensional, and a typical coastline can be 1.213 dimensional. Whoever heard of a seacoast having a fractional dimension? But so it has. Fractals arise in many problems: the distribution of galaxies, the patterns of errors in transmission lines, the behavior of liquid crystals, the scattering of radar beams by mountains. The massive single-minded achievement of Mandelbrot is to have exhibited an entire new regime of mathematical modeling applicable to a wide range of natural phenomena.

Since 1974 Mandelbrot has been an IBM fellow—an official recognition of his influence on ideas that at one time seemed wild tangents. He does not have the proverbial corner office, though. In the smoothly curving glass of Thomas J. Watson Research Center at Yorktown Heights, New York, there aren't any. That doesn't matter to Mandelbrot, because he knows he's at the center of a rapidly branching web of science and mathematics. *Branching web* is an inadequate description for a structure only a fractal—or Mandelbrot himself, in his gleefully kaleidoscopic style—could describe. So writer Monte Davis asked him to look over the shape of his career for *Omni* and to describe the importance of being tessellated.

Omni: Your first fractal simulations were of graphs. Why was it important that they look so realistic?

Mandelbrot: When scientists need to convince others, they use words and formulas. So do I, but I also use pictures. This was sternly discouraged when I was training to become a scientist. In fact, I first became aware of the power of the eye very late, around 1968, when I was working on the "Joseph effect." This is the name I gave in jest to the persistent fluctuations in the levels of the Nile, like the "seven fat years and seven lean years" described in the Bible. The foremost Nilologist of all time, an Englishman named Harold Edwin Hurst, had spent the bulk of his career in Cairo analyzing the records of the Nile's high- and low-water levels and had made important but highly mystifying observations about the river. A friend described these observations to me and challenged me to do something about them. On the foundation of Hurst's data, I developed a statistical model to account for the basic features of the Nile and of other rivers. I later went on a kind of pilgrimage to meet Hurst, nearly one hundred years old at that time.

The main feature of the Joseph effect is that the successive yearly discharges of the Nile, like that of many other rivers, are extraordinarily persistent, but people had long since stopped trying to predict where a river's level would be next year. A statistical approach was needed, but none of the textbook models of hydrology and statistics remotely fit Hurst's observations. My own model did fit, but it had an awkward feature. In order to achieve this fit, I had to break certain mathematical assumptions and to replace them by assumptions that looked abstract, were hard to understand, and thus hard to accept.

So I teamed up with a hydrologist to develop my model and make it more acceptable. One of the first things we did was to plot the actual fluctuations, using not only the original data of Hurst but also a collection of deliberate forgeries—records of nonexistent rivers constructed to obey my model. The outcome of this experiment was that everyone who tried to sort out our collection of graphs had to agree that my model was extraordinarily effective in mimicking nature's erratic fluctuations, which I called Hurst's noise. At long last the model I'd constructed was taken seri-

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FICTION

DESERTED CITIES OF THE HEART

BY LEWIS SHINER

PAINTING BY JAMES CHRISTENSEN

As the helicopter settled into the jungle clearing, Ryker could feel his promises slipping away from him.

The worst, he thought, was the promise to himself. He'd sworn he would leave Lindsey alone, stay out of her life. And yet here he was, running to her the first time she called.

The pilot sprung the hatch, and the hot, thick air of southern Mexico washed into the cabin. Ryker struggled with his harness, still disoriented by the high technology of the ship: holographic guidance systems, compressed, tasteless food, the abstracted courtesy of the crew.

Of course, he thought. *It took her five years to call.*

Camarena, the field director of the expedition, was waiting for him as he stepped down. Lindsey had mentioned her in the letter, warning him that Camarena was hostile to the entire mushroom experiment and hadn't wanted Ryker to come.

"Buenas tardes," Camarena said, extending her hand. Her hair was pulled into a tight, black knot, and her khaki work clothes were impossibly crisp.

"Buenas," Ryker said, conscious of his worn jeans and the frayed elbows of his dingy shirt. He wondered why Lindsey wasn't there to meet him, and then decided it was better this way, that they both probably needed the extra time.

Camarena led him uphill, out of the grassy plain and into the jungle. A few turns of the steeply twisting path were enough to cut them off from the landing area. Eerie insect harmonies drowned the noise of the copter, stranding them in the timeless heat of the Mayan highlands.

Pieces of fallen temples littered the jungle floor, green with moss and half-buried under decaying leaves. Mahogany, fig, and ramon nut trees arched up to an invisible roof a hundred feet overhead. Through the veils of branches, Ryker could glimpse a stucco hand or carved helmet: elements of a gigantic unsolved puzzle.

Camarena hesitated, impatient, and Ryker tried to pick up his pace. "Coming," he said in Spanish.

He'd forgotten so much. The perfect stillness of the air, the beauty of the ruins in the watery green light. Five years ago, when he'd first come to the jungle, all the answers that he'd been looking for had seemed so close.

Five years ago. A shard of memory cut him deeply and without warning. He saw himself and Lindsey in the tiny apartment they'd shared in graduate school, sitting on the floor by the kerosene heater, their knees just touching. Lindsey's robe hanging open to show the flush still lingering on her breasts, her long red-blond hair hopelessly tangled, the smells of sex and their mingled sweat binding the two of them like a magnetic charge.

Ryker winced and pushed forward.

The path opened suddenly into a clearing about forty meters across. A dozen or so foil hemisphere tents were set out in a rough circle around the ashes of a campfire. The clutter on all sides of the tents looked like a fashion photographer's idea of a layout for a computer ad. Video terminals sat on carved blocks of limestone, and the map lights of several processors blinked through the clear walls of a bubble tent nearby. Various electronic scanners, cameras, and measuring devices, half of which were completely mysterious to Ryker, were strewn near the clearing.

Most of the work was going on back in the jungle. Ryker heard a mixture of voices and languages: English, Spanish, Russian, and others too slurred to identify. The only person working in the clearing was a Japanese who was typing furiously at one of the CRTs. Camarena introduced him as Oishi, saying, "He designed and built most of this equipment himself."

"Konnichi wa," Ryker said, bowing awkwardly then switching to Spanish. "Things have changed in five years."

Camarena led him uphill, out of the grassy plain and into the jungle. Eerie insect harmonies drowned the noise of the copter, stranding them in the timeless heat

Oishi returned his bow and answered in English. "One becomes obsolete so quickly these days."

Obsolete. Before Ryker could decide if the insult had been intentional, Oishi had turned back to his keyboard, and Camarena was excusing herself. "Make yourself at home," she told him. "If you need anything, just ask one of the students."

Ryker thanked her and watched her walk away. If was politics, he knew. The Mexican government, particularly the powerful *Instituto Nacional de Antropologia e Historia*, had been won over by the recent breakthroughs in parapsychology. They began insisting that every expedition include a member trained not only in appropriate myths and folklore but with a general occult background as well.

The last time Ryker had seen Lindsey, she was close to getting her Ph.D. in anthropology, but her letter said she'd taken advantage of the new laws and become a parahistorian instead, with Aztec and Mayan specialization.

Since the nearly bankrupt United States government hadn't funded any fieldwork in over a decade, it had seemed like her best chance of getting on a major dig.

But once she had the job, she had to contend with the prejudice of the old-line archaeologists. Camarena included, who resented her influence. Not to mention the fact that she resented *norteamericanos* living off Mexico's newly stabilized wealth.

Now, because of his fluency in Mayan, Lindsey had brought Ryker into the middle of it. And he'd let her, because of the incredible finds the expedition had made.

They were all around him. At the west end of the camp a steep-sided pyramid over twenty-five meters high was slowly emerging from centuries of dirt and vegetation. Erosion had softened its outlines and loosened most of its stones, but Ryker could still make out the mushroom-shaped designs carved into the steps.

He crossed the clearing and stopped in front of the "palace," an intricate complex of fallen walls on a ten-meter raised platform. Two stelae had been laid out in front of it, and Ryker knelt to read the inscriptions on the nearest one. The date placed the carving right in the middle of the Classic Era, but as Ryker's eyes traveled down the limestone slab, he saw a series of glyphs he'd never seen before, all centered around one he knew especially well.

The mushroom.

The Mayan use of sacred mushrooms had been common knowledge since the last half of the twentieth century. But no one had imagined that there had been an entire ceremonial center devoted to their use, not until Camarena began to turn up the indisputable evidence.

Ryker straightened up, and the images seemed to lunge at him—here an umbrella-shaped stucco design, there a complete, three-dimensional fungus, carved from limestone and two meters high. He could hear the blood hammering in his ears, and when he felt a hand on his arm his muscles jumped and he flinched.

Lindsey pulled back from him, saying, "I'm sorry. I didn't mean to—"

"Lindsey," Ryker said.

"Are you okay?"

"Nerves," he said. "Sorry. I jumped—"

"My God. You look terrible."

Ryker had no answer to offer her. Her own beauty had softened, grown lines around the eyes, become tired and a little sad. Her hair was cut short now, revealing unfamiliar planes and angles in her face. She was more of a stranger to him than Camarena had been. There was so much he no longer knew about her, so many dangerous assumptions to avoid.

"I'm sorry," she said. She looked off into the distance, and Ryker could read emotion stinging at her eyes. "This isn't going well at all."

"I shouldn't have come," Ryker said.

"No. You saw the stelae and the carvings. You read my letter. You had to come."

"I guess so."

"Did Camarena show you the plants?" Ryker shook his head. "Come on then. You should see them."

They took another path away from the clearing, and the clatter and whine of Oishi's electronics faded behind them.

Lindsey was the first to break the awkward silence. "I've kept track of you, you know," she said. "Peter told me you'd gone off into the jungle with the Lacondones. Some kind of grail quest thing, he called it. I suppose I understand that well enough. I just didn't understand why you never told me about it yourself. You could have sent a letter back with Peter. Or something."

Ryker had dreaded this, being forced to justify what he'd done. From Lindsey's point of view it was inexcusable. They'd been living together, been in love or something like it, and then he'd gone on an expedition into Mexico and not come back. For three years he'd lived in the jungle with the last tribe of Lacondones, the last uncivilized Mayan people. He'd hunted and fished with them, followed them on their pilgrimages to the abandoned city of Yaxchilan, mastered their language, obsessively pursued their shadowy gods, the *Yumil Qax ob*, the Lords of the Forest.

Then he spent two years at odd jobs in Palenque and Piste and the other little towns near Mayan ruins, living off of a black-market work permit, the bright urgency of his desire tarnished and nearly unrecognizable.

"Every so often," Lindsey went on, "I'd hear something about you. That somebody'd seen you waiting tables in Villa Hermosa or guiding tours at Bonampak. But there were never any messages, never any explanations."

Ryker was a step behind her on the narrow trail, and he took her arm to stop her. "Don't you think," he said, "don't you think I would have explained it if I could? Didn't it ever occur to you that it wasn't something simple and rational that you could label and process and quantify?"

"You could have tried," she said, still facing away from him, looking at the dead leaves under her feet. "You could try now."

"I don't know," Ryker said. "I don't know where to start. One day I woke up, and a lot of things that shouldn't fit together started making a weird kind of sense."

"What things?"

"Politics. Economics. The whole thing. I mean, the United States used to be the most powerful country in the world, and now look. Roads shot to hell and no money to fix them. No oil. No manufacturing. The economy in ruins, the air and water polluted beyond recovery. And it all happened almost overnight. Then I looked at the Mayans, the greatest power of their time. They invented the zero, had a more accurate calendar than we do, had all this incredibly advanced astronomy and architecture, and between about 850 and 900 A.D. it all just disappeared."

"And you think there's a connection?"

"Not ... a connection. But something. A clue. Some knowledge that could make sense of what's happening to us. You know? For five years I've been chasing this—I don't know—this premonition, this sense of destiny. And back there in the camp I could feel it again, stronger than ever."

Finally she turned to face him. "Can't you see how ridiculous this sounds? You're killing yourself by inches. You don't weigh enough to walk against a stiff breeze, you jump out of your skin at the slightest noise, your eyes look like they've sunken clear through your skull, and it's all over some screwy vision that you got from eating magic mushrooms."

Yes, Ryker thought, *he'd eaten his share. Psilocybe cubensis and Amanita muscaria. And the datura plant, Jimsonweed. And the bitter buttons of peyote and the morning glory seeds that had brought visions of death and apocalypse to the builders of Teotihuacan. And mescal and hemp and even aguardiente, the powerful sugarcane brandy of the Mayan highlands. But none of them had ever been able to give him more than even a fragmentary glimpse of what he was looking for.*

Ryker straightened up, and the images seemed to lunge at him. He could hear the blood hammering in his ears, and when he felt a hand on his arm he flinched away violently.

Lindsey sighed and turned away. "Come on," she said. "They're right over here."

Some of the mushrooms were no bigger than Ryker's hand, others nearly half a meter tall, all of them tinted in shades of red and gold.

"They're beautiful," Ryker whispered. "And there aren't any others?"

"We've never found any. When we tried to transplant them, even in plugs of soil, they started to wither within a couple of hours. I'm convinced there's something about this specific spot that's more than just the chemistry."

"Any clue in the inscriptions?"

"We're not sure. We know this is the plant they're depicting, but we can't figure out what they were saying about it."

"I wonder what it's like—" Ryker said, not even aware that he'd put the thought into words until he saw Lindsey's face.

"Don't even think about it," she told him. "One of the students, some kid from Vermont, tried it. We watched his brain burn out. He's a vegetable in a mental ward now."

"But the natives—"

"The natives can handle it. It it's doing what we think it is, and tapping some kind of ancestral memory, then the ancestry has to be absolutely pure. If there's any kind of racial mixture, then the brain just can't cope with the confusion."

She glanced to the west and said, "We should be getting back to camp. It'll be dark soon."

"The start of a new day," Ryker said.

"What?"

"The Mayans," Ryker said. "Their day started at sunset."

"Oh, yeah. Right. Well, maybe today will be the day our Indian shows up and we can get this damned experiment rolling."

The campfire looked out of place in the middle of Oishi's technological marvels, but Ryker could appreciate its primitive comfort. He stood just outside the circle of light, drinking Bohemia and listening to Camarena hold forth on the United States.

"*Los Estados Unidos*?" she said. "*Se acabo*. It's all over. In your big cities the people live like animals. They burn their furniture to keep warm. Your cars rust on the side of the road. Now it is Mexico's turn. Now we have the wealth and the energy and the ideas."

Dream on, Ryker thought, moving away for another beer. *You're just making the same mistakes a little faster.*

From the opposite side of the circle he could hear Lindsey's voice, relaxed now, in her proper element. "... destroyed by jaguars," she said, "killing off all the race of giants." He could see the firelight turning her skin translucent, lighting the bones underneath. He found he could not look at her without being swamped by strong emotions—guilt, desire, a gnawing curiosity about her last five years.

"The second sun was wind," she said, "ending with a hurricane. The survivors were turned into monkeys. The third sun was fiery rain, and the survivors were birds. Then the fourth sun was water, with a flood like in the Old Testament or the Koran, and the survivors became fish."

A voice asked, "Where do we come in?"

Her right hand pushed at her hair, a gesture from Ryker's memories that forced him to turn his head away.

"We're next," Lindsey said. "The fifth sun. Movement. At least that's what the Aztecs call it." She sketched a symbol in the dust that looked like a block X with an eye in the center. "You've all seen that. The *Instituto Nacional de Antropologia e Historia* took it for their symbol. We know the Mayans believed in something similar, but we don't know exactly what it was. We do know for sure, though, they had the concept of periodic disaster and renewal."

Disaster and renewal, Ryker thought. *Disaster and renewal.*

He turned away from the fire and walked quietly into the forest. The full moon barely penetrated the roof of trees, but it was enough for Ryker to find his way back to the mushroom grove.

Kneeling in front of the biggest plant he

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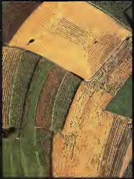
From the perspective of an eagle, the earthworks of man and nature coalesce in high design

AERIAL ABSTRACTIONS

BY ANTHONY WOLFF

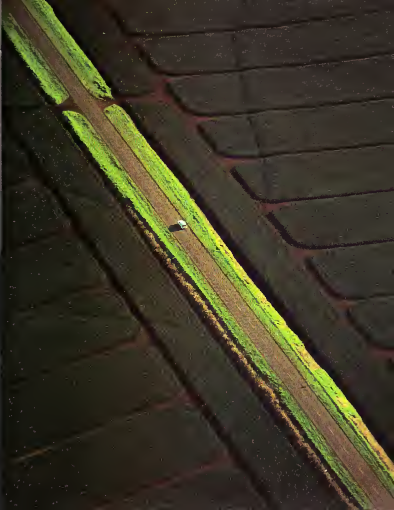
“Distance creates a kind of clarity and transforms the single image into a symbol”



Hanging between heaven and Earth at what he calls the medium altitudes, Georg Gerster makes stunning photographs that transcend mere picture taking and become beautiful abstractions. His single-minded passion is to find the right height and the right light to reveal the designs and colors that man creates as he revises the landscape. The bird's-eye view of the earth is special to Gerster. "The distance creates clarity," he says, "and transforms the single image into a symbol."

The Swiss-born photographer is ever mindful of the practicality of his images, even as he seeks them out for their beauty. The rusty orange hues that tint the shallow salt ponds of San Francisco Bay (preceding spread, left) are caused by microorganisms that bloom in the brine. The color is a natural litmus test of salt concentration. The sinuous downhill-slalom design (preceding spread, right) was etched in a fallow wheat field by a Kansas farmer who, as Gerster likes to point out, created it for erosion control, with no thought of aesthetics.

Over Switzerland's Jura Mountains, Gerster's high-flying Nikon records the crazy-quilt image of a jumbled section of mountainous farmland (left). Sadly, such ingenious land-use systems, dictated by the local ecology, mountain terrain, and traditional patterns of land ownership, are uneconomical and fated to disappear, Gerster says. The modern solution, in which man's order is imposed on the landscape, now prevails. It is symbolized by the mechanized monoculture of a pineapple plantation (right) on the island of Oahu, in Hawaii. Its uniform composition makes for a compelling piece of earth art.



"The farmer draws with his plow and harrow. He paints with the colors of his crops."

The farmer, says Gerster, is a great earth artist: "In his plastic, monumental effect, some of his works surpass the most beautiful architectural creations. The farmer draws with plow, harrow, and combine; he paints with the colors of his crops. The shapes and hues of his world seem inexhaustible from the air. It is as if the farmer had found the philosophers' stone, which he uses to turn ordinary earth into visual gold."

Gerster captured a sample of this optical alchemy near Salt Lake City, as he looked down on swirling fingers of gold, actually winter wheat, growing in the desert (left). The crop, as Gerster discovered, had just been harvested. The gold on the ground is the stubble left behind by the reaper. It acts as a protective blanket, holding in moisture and shielding the topsoil from the eroding desert winds. In an area east of Hamedan, in Iran, a darker hue (right) of golden wheat seems to flow from a man-made crater, thought to be part of an ancient water system. Over the long, cold winters enough snow accumulates in the mountains to assure farmers two wheat crops a year.

Gerster sees his photographs as recordings of the "ecological give and take" between man and the rest of nature. Although the struggle has often been lopsided and has taken a heavy toll on the planet, he remains hopeful. "The current popular condemnation of man, which sees him as an incurable disease of his own planet, passes judgment without trial. I regard my aerial photographs as the interrogation of the accused," he says. "But if they plead at all, it is for one who has built up, rather than against one who has destroyed." ∞

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come Tevatron. Wilson envisioned using a novel kind of magnet.

"For a new machine, it made sense to use our existing tunnel," says Toohig. "But for higher energy we needed more powerful magnets, a new technology."

Magnets are key synchrotron components, guiding particles around the ring and focusing them into a tight beam. But conventional electromagnets are limited by electrical resistance. Wilson thought that superconductors might be the way to break through the limits.

Superconductivity is a peculiar state in which—for reasons still unclear—certain substances lose virtually all their resistance to electricity. So they can sustain magnetic fields that are intense and rock steady. But superconductivity requires temperatures approaching 0° Kelvin (absolute zero). For Tevatron to work, designers would have to figure out how to maintain 1,000 magnets, each about 20 feet long, at 4.6° Kelvin (−451°F). In 1972 superconducting magnets were mere curiosities in university laboratories. But that year Wilson announced boldly that they could work—and *would* work—in a real-world synchrotron.

Fulfilling Wilson's dream wasn't easy. "We had to overcome painful problems," says physicist Paul Mantsch, who helped develop the new technology.

Guiding a visitor through the factorylike assembly buildings, Mantsch points out that each magnet assembly, about the size of a canoe, has a hollow core—the beam pipe through which the particles whiz—wrapped with superconducting coils, which look like pythons that have been flattened by bulldozers. Because these coils shape the magnetic fields that guide the particles, they must be wrapped accurately to 0.002 inch. And they must stay that way.

The coil-wrapped beam tube, as big around as a football, sits in a larger tube containing liquid helium at temperatures close to absolute zero. As the helium chills the niobium-titanium coils, they shrink, which could shift the field. FermiLab solved the problem with spring-based "smart bolts" that maintain a steady pressure, keeping the coils aligned.

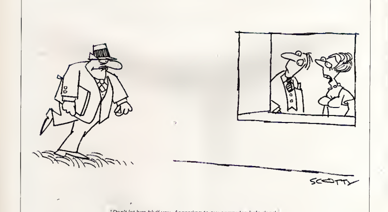
Even trickier is protecting magnets against the dreaded "quench." A quench can result when a hair-thin wire in the magnetic coil twitches under magnetic stress, loses superconductivity, heats up, infects its neighbors, and warms the entire magnet. No longer superconductive, with heavy currents pouring in, the magnet can melt. And as one FermiLab physicist points out, "The collective energy in the superconducting magnets equals one thousand sticks of dynamite." Designers solved that problem with precisely stamped metal collars that immobilize the coils.

FermiLab soon became one of the world's largest consumers of superconducting wire. "And when we built a helium liquefaction plant, we doubled the world's production of liquid helium," says Mantsch. Helium, the physicist says, "was a whole other can of worms."

The new Tevatron ring is a four-mile conduit for liquid helium. "It's an incredibly complicated device," says Mantsch.

Temperatures inside must be uniform to one tenth of a degree Kelvin. If a mishap leaks liquid helium into the tunnel, it abruptly expands, crowding out oxygen with a whoosh. That is why technicians patrolling the subterranean tunnel in golf carts resemble futuristic warriors. Just in case, they always carry yellow oxygen masks and alarms that whistle if the air is forced out by helium.

Before Tevatron, protons inside the main ring would accelerate up to 400 GeV. Then they would shoot through pipes to experimental stations, where they would smash into targets. Physicists would examine electronic snapshots of those explosions, looking for the telltale paths—resembling jet vapor trails—of new subatomic beasties blown out from the impact. Now, however, the old main ring is merely the fourth step in the cascade system, feeding par-



"Don't let him bluff you. According to our computer he's dead."

ticles at 150 GeV into the superconducting Tevatron ring mounted just a few feet below it in the tunnel The energized particles glide into the Tevafron ring much as cars move down an entrance ramp onto a turnpike And these minuscule vehicles pay only a tiny toll

Say *Tevatron* and FermiLab s bookkeepers smile Thanks fo superconductivity the new system cuts the lab s annual electric bill by a whopping $5 million Yet in the instrumenf-jammed control room a windowless twilight zone where banks of CRT screens forever exchange meaningful winks and blinks the computers human overseers can now crank up their magnets to power levels bordering on the eerie Tevatron has already hit 700 GeV By 1986 after modifications are complete the ring will contain two beams proton and antiproton, circling in opposite directions Then for fhe edification of physicists the two beams will collide creating a 2-TeV smack-up Sifting the debris from the collision physicists expect to find all sorts of previously undiscovered little animals high-tech s gift to science

One of the greatest technological achievements in the world is right outside that window says theoretical physicist Christopher Hill, opening the blinds of his office high up in FermiLab s central skyscraper and showing off the view of the mound marking the synchrotron beneath the prairie In the control room far below Hill s office, banks of screens display graphics and digital readouts status reports on the miles of proton beams in the five accelerators, the thousands of ordinary electromagnets and superconductors the cryogenic systems the RF cavities—too much for human control As Toohig puts it 'To run the acceterafor we have about four hundred microprocessors tied in to the cenfral computing system There are minicomputers talking to the mainframe maxicomputers talking to the minis and more minis talking to them Tevatron s only possible rival for technological complexity is the space shuttle

But for theorists like Hill this grand machine is only a superscrewdriver just right for prying open the hard nut of subatomic particles Inside he and his colleagues hope to find new forces and new particles that were invisible at lower energy levels Ultimately, however, they have high hopes of finding much less

Once physicists thought they had the world solved Everything was made of atoms, which consisted of electrons orbiting a nucleus of protons and neutrons Then researchers built more potent accelerators "It's a kind of paradox of nature to study fhe very smallesf objects we must construct the largest of scientific instruments says Hill Using these ever more powerful "microscopes, physicists looked inside the elementary particles and found more particles The subatomic zone proved to be a jungle inhabited by as many as 200 elementary particles ' Governing

the interactions of these particles researchers discerned four primordial forces the electromagnetic force (light is one manifestation) the strong force (it binds particles into atomic nuclei), the weak force (responsible for radioactive decay), and gravity

But this image of the cosmos had a fundamental flaw at least to physicists it was messy and inelegant

Theoretical physicists theorized further Experimental physicists constructed even more-potent accelerators and tested their theories The results satisfying to all were glimmerings of simplification

It is possible today to do better than the ancient Greeks, who thought everything was earth air fire and water Today's physicists have shortened the main list of elementary things

According to current belief, all the world is quarks and leptons

Quarks are the building blocks of all atomic pieces governed by the strong nuclear force Protons for example—the positively charged particles in the nuclei of atoms—are made of quarks Leptons are atomic particles not governed by the strong nuclear force They have no internal components so far as we know Electrons are one species of lepton

But the simplifications are not yet elegant enough to appear on a T-shirt When Hill sets out to sketch on a blackboard the bare outline of physics' current worldview the empty space quickly fills with symbols and the chalk wears down to a nubbin Hill acknowledges one reason for the complexity too many quarks and leptons '

Quarks (the whimsical name was coined by American physicist Murray Gell-Mann) come in "flavors," reflecting their different electrical charges and masses And each flavor comes in one of three "colors" or degrees of freedom

In recent years quarks have begun to multiply like rabbits Physicists have identified entirely new "generations" of quarks There are charmed quarks beauty quarks and the seemingly redundantly named strange quarks—all displaying different physical masses but having similar patterns of colors and flavors Worse leptons seem to come in two "flavors" themselves More complicated still every quark and lepton seems to have an antiparticle—a particle with equal mass but opposite electrical charge Elegance appears to evaporate How can Hill talk seriously of simplicity while his blackboard turns white with chalk trails?

Hill and others base their optimism on results from recent accelerator experiments In a sense today's equipment enables physicists to look further back in time to the moments after the universe's creation in the Big Bang before particles coalesced into the atoms now composing matter In the minute fractions of a second after the Big Bang energy levels were higher than anything in today's universe The new accelerators—generating energies greater than those existing at the centers of stars—provide tantalizing glimpses of those early fractions of a second, when matter existed only in its primal form

Recent work has led researchers to embrace a new creed about the forces determining how all matter combines and reacts Physicists now believe that electromagnetism, the weak force and the strong force are all manifestations of a single kind of force "We now think we understand in principle how all the interactions [of particles and forces]—except for gravity—work And we have hints about even that" Hill says

Two announcements in 1983 from CERN gave a boost to the theory that several apparently different forces are really one force The theory predicts the existence of three previously unknown particles called bosons Bosons mediate or carry force About a year ago CERN announced it had discovered one of the predicted particles the W boson Last May researchers reported finding evidence of a second the Z zero particle The findings gave CERN a commanding two-to-nothing lead in the race toward confirming a grand unification theory But Tevatron has put the United States back in the contest

"The next experiments here at FermiLab will make lots of W and Z bosons and will study the strong force and the electroweak force " says Hill "Could it be that all the various quarks and leptons are really just composites of simpler smaller particles? The Tevatron will give us a chance to explore this possibility, because we can now magnify matter down to a thousandth the diameter of a proton

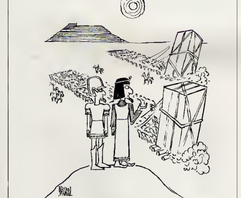
But can physicists live on 2 TeV alone? Apparently not Hot on the trail of their unified-field theories they are building or planning powerful new accelerators all around the world

• California is upgrading the Stanford Linear Accelerator a consortium of universities is building a new electron accelerator in Virginia Brookhaven National Laboratory is planning to convert its proton synchrotron into a heavy-ion accelerator that will smash atomic nuclei together Yale University is building an "extended, stretched transuranium accelerator"

• Japan and China are building new accelerators the USSR's new UNK will yield 400-GeV collisions by 1988 with projections for 3 TeV by the Nineties Germany is building HERA (Hadron-Electron Ring Accelerator) to slam electrons at 30 GeV with protons at 820 GeV, CERN is building LEP, which, at 120 GeV will be the world's most energetic electron-positron collider

• At Los Alamos Scientific Laboratory, Brookhaven Sandia Laboratory, and other centers, physicists are contemplating completely new kinds of accelerators in which the particles will be propelled not by radio waves but by lasers

But the most awesome project will be



"It's the perfect system It guarantees full employment on the one hand without the commensurate rise in inflation on the other"

the SSC In this 100-mile-circumference unit two proton beams will collide at 40 TeV Because they want the SSC so badly the physics community recently made the difficult decision of scrapping Brookhaven's half-finished colliding-beam accelerator. Essentially the SSC will borrow the superconducting-magnet technology that would have gone into the Brookhaven machine and that now drives FermiLab s Tevatron But there will be differences in the advanced smashers of the future

We could make the SSC like the Tevatron but we built the Tevatron dumb Why not use what we learned to make the SSC better? says Lederman

Why spend perhaps $2 billion to build a gargantuan machine to squash particles so tiny that nobody will actually ever see them, only their tracks on electronic detectors? 'I wouldn't tell a congressman but it's really because our current picture of the world is aesthetically flawed by complexity There are just too many particles says Lederman 'For one thing we don't understand diddly about the masses of these things

He says that the higher energy of the new machine will enable physicists to better examine the moment of creation Today he points out gravity is relatively unimportant But then when the universe was smaller than an amoeba gravity must have been a key force Thus the SSC may enable physicists to unify all *four* forces into a single satisfyingly elegant force In addition says Lederman the new machine should help physicists understand the structure of particles

Ever since 1900 we ve been sweeping certain problems under the rug—for instance How can God make an electron? he says 'I think we'll find that the electron has particles inside because I'd like to see the whole thing boiled down to just one force and two things, with no more little people in there

'If you collate all the different physicists predictions as to where to look Lederman continues they seem to peak at a certain energy level

That happens to be the energy level at which the SSC would operate Not that building the mammoth SSC will be a snap Getting that beam around the ring and back to within a millimeter or so of its starting point and doing it fifty thousand times a second is something like aiming a rifle at the eye of a mosquito on the moon he says Damn! I hit the wrong eye!'

Yet it is worth trying he believes It could be the end of a search that began in prehistory when humans huddled around campfires at night and wondered why it gets light every day The results of developing a unified-field theory that reduces the entire physical world to two particles and one force, while unimaginable are sure to be profound

Lederman puts it like this 'I think we're on the threshold of finding God, or at least His greater glory ◘◘

INTELLIGENCE

CONTINUED FROM PAGE 24

ACS clerks never have to touch a sheet of paper The computer selects the highest-priority accounts and presents them one at a time on the screen All the clerk has to do is tap the key marked DIAL and the computer automatically calls the person's number. It the line is busy or if there is no answer, the computer reschedules the call and puts the next account on the screen Taxpayers who are not reached the first time may be telephoned automatically as otten as every 15 minutes until someone picks up the phone

When a call goes through the clerk tells the taxpayer exactly how much he owes in taxes and interest If the individual promises to pay by a certain date the clerk enters the information on the computer If no payment is received ACS will continue its electronic dunning until the taxpayer complies. Those who ignore the ACS computer get a visit from a collection agent, live and in person

In 1976 the IRS had 614,000 delinquent accounts in 1982 there were nearly 2 million Over the same period the amount owed to the government in back taxes and penalties grew from $1 7 billion to $7 6 billion With ACS, Uncle Sam is trying to cope with the rising number of people who fail to pay their taxes on time

With electronic collection at hand electronic audits are only a step away In 1982 the IRS examined 1.7 million returns and recommended additional taxes and penalties of $11 7 billion By using the sort of technology that made ACS possible the agency believes it will be able to increase the number of audits by 505.000 a year And more audits means more revenue

The IRS is also using its computers to try to crack the so-called underground economy—the exchange of cash and services that does not get reported on information documents Commercial lists based on family income and home address have long been used by merchandising firms to sell luxury items The IRS is now experimenting with those same lists, matching them against its computerized master files to catch people who make more money than they report

Though some civil libertarians believe that sort of matching operation constitutes an invasion of privacy, Heironimus disagrees "The use of this kind of technique is certainly not new," he says "We have used it in limited forms to determine vehicle registrations in the highway-use-tax program

Ever sensitive to public relations, IRS officials are reluctant to speculate about how much more money their expanded computer operations are likely to net from delinquent or cheating taxpayers. But with annual federal deficits of $150 billion to $200 billion government managers are enthusiastic about using the most sophisticated computer gear allowed by law to hunt for bytes of income

NEW WARES HARD AND SOFT

Stress smoking and poor eating habits cost American businesses more than $100 billion a year in direct employee expenses and lost productivity To encourage workers to adopt healthful life-styles, Control Data Corporation is offering companies a computer program called *Plato Staywell* Using their own (confidential) computer diskettes and a touch-sensitive screen linked to a Control Data 110 microcomputer participants answer questions about their problems and their goals The program responds with a course of action specifically tailored to each person As individuals update their computerized records, the program provides them with additional recommendations (From $20 to $50 per employee depending on hardware and software requirements, from Control Data Health Care Services Life Extension Division Box 0—HQC02P, Minneapolis MN 55440)

"Buy low sell high" That's the not-so-secret formula for making money in the stock market PC+ Products hasn't changed the formula But it has put together a computer program to help investors and technical analysts plot—with optional color graphics—the ups and downs of their portfolios and to make wise decisions *Wall Street Window* operates on the IBM PC or any clone equipped with twin disk drives It draws data directly from the Dow Jones or CompuServe networks The program can keep track of 112 stocks on a floppy disk a common storage medium for electronic data Or in more expensive systems, it can follow the entire New York Stock Exchange with a hard disk, which has many times the capacity of the average floppy ($395 for *Wall Street Window* and $559 for the ColorPlus Graphics Board, from PC+ Products 1751 McCarthy Boulevard Milpitas CA 95035.) ⌧

True to UFO lore, the design calls for a domed, saucer-shaped ship propelled by powerful magnets

ANTI MATTER

UFO UPDATE

There's a faint buzzing, an eerie glow and the crackle of static electricity as the craft rises from the ground. Its shape tips it off as some strange flying saucer. Yet the vehicle comes from Earth.

The scene springs from the imagination of computer expert Jen Pajak, who says he's found a new way to rocket a vehicle to space at unheard of speeds. Now a computer instructor at Southland Community College, in New Zealand, Pajak received his training and inspiration at the University of Breslau in his native Poland. There, Pajak says, he and other engineers began designing a spacecraft to run on magnetism instead of conventional rocket fuel.

After perusing the elusive design for years, claims Pajak, his group finally agreed upon the shape of the ship in the mid-Seventies. True to UFO lore, he says, the design calls for a domed, saucer-shaped ship containing a powerful magnet whose orientation would determine the direction of flight. Positioning the north pole of the craft's magnet directly over Earth's North Pole, for example, would make the ship rise. At the same time, the rim of the saucer would contain a number of smaller electromagnets in the opposite orientation from the main magnetic drive—an arrangement that would prevent the craft from flipping and plummeting helplessly to the ground.

"This gives a full explanation of how UFO propulsion works," says Pajak, adding that magnetic drive would work even in deep space. There, the pilot would switch on a drive to pulse the powerful magnets, creating a swirling magnetic field that would pull the vehicle through space in much the same way as propellers pull an airplane through air.

Pajak's idea may sound attractive at first—magnetic propulsion has long been a favorite cult explanation of how UFOs fly—but other factors interfere. For one thing, the magnets he proposes—hundreds of thousands of times more powerful than Earth's magnetic field—have never been created. Moreover, if such magnets did exist, they'd probably generate enough heat to fry any living thing in close proximity. And charging the vehicle's magnets would require enough energy to supply the needs of a small country for a year.

Worse, however, is that the design runs smack against the most basic tenets of modern physics. As any student of elementary physics knows, says the nation's foremost magnetics expert—Henry Kolm, of the Massachusetts Institute of Technology—magnetic fields are not straight but curved, so no matter how the magnets were placed, the ship would twirl around rather than move forward. Furthermore, the earth's magnetic field is far too weak for any magnet to lift off from it at all. "It would be like pushing against nothing," Kolm adds.

Pajak, however, is undaunted by even the most penetrating criticism, and vows to pursue his dream ship. Step one, he says, involves tracking down a source of funds as colossal as the magnets themselves. "It will take billions," he says, "but we might well see a Magnocraft in the not-too-distant future."—*LISA MITCHELL*

"Our highways are filled with hordes of degenerates and psychopaths says George Eriksen a veteran of demolition derbies "Anybody can be attacked by human scum

Author of *Getaway* a manual on driving techniques for escape and evasion Eriksen points out that a motorist can avoid such scum by drilling a hole in his car s exhaust manifold and welding a can of castor oil to it The castor oil is installed under the dashboard and connected to a hand pump, Eriksen explains "So if your car is being followed you can blind your pursuer with smoke by pumping the oil into your exhaust

But if you re the kind of motorist who doesn t like punching holes into a new Porsche, Eriksen has some advice for you as well Human scum won t normally chase you down the street anyway, he claims ' Instead they ll stand with automatic weapons at roadblocks and get you when you stop To avoid them just use the 'bootleggers turn Here's how "Simply approach the blockade at thirty miles an hour and crank the steering wheel to half a full turn says Eriksen Then hit the emergency brake until your vehicle skids into a ninety-degree angle Release the brake straighten the steering wheel and hit the gas hard to swing the car to a one hundred-eighty-degree U-tur

Since the turn causes incredible wear and tear on your tires Eriksen warns 'you should practice this maneuver only on a rented car Just don t tell the rental company what you're planning to do

Finally Eriksen gives motorists everywhere a bit of advice If your attackers get in your way *remember* just run them over For a copy of *Getaway* send $4 95 to Loompanics Box 1197 Port Townsend WA 98368 —Peter Rondinone

SOLOMON'S MINES

Browsing In Brazil s national archives Rene Chabbert, a retired Air Force electrician stumbled across a letter written in 1 53 The authors were Portuguese-explorers claiming they d discovered the stone vaults of King Solomon's gold mines (long thought to be hidden at various sites around the world) Now after 18 years of research Chabbert believes he s pinpointed evidence of the long lost mines In a gray mass photographed by a U S weather satellite over the Brazilian jungle

But Harvard professor Barry Fell an Old World scholar who has examined Chabbert s evidence says "I myself don't think he s found the stone vaults of a gold mine While it s true that stonework photographed from satellites appears gray It s also true that water will appear gray And since Chabbert s gray mass is in a tropical rain forest I m sure he s looking at a high concentration of water

Fell admits the letter includes symbols from an alphabet used by Egyptian priests around the time of King Solomon In fact he adds of the two words translated one was *silver* and the other *gold* 'Even so says Fell, archive officials assured me the letter was a hoax '

But Chabbert maintains that the Brazilian government is lying The reason There s still a dispute over who discovered Brazil first The Portuguese claim that Pedro Cabral sailing for the East Indies was blown off course and reached Brazil in 1500, Chabbert explains Yet the Spanish claim that Vicente Pinzón who commanded the *Niña* on Columbus s first voyage to the New World also sailed to Brazil in 1500 'Let's face it," he adds 'nobody wants Solomon screwing up their heritage even more "

Right now says Chabbert, his major stumbling block is the Brazilian government itself ' Unless I can get the support of at least one respected scientist, he says ' officials won t let me bomb the jungle to clear the trees out so I can build a Vietnam-style heliport and get the treasure "

Toward that end, Chabbert is now asking NASA to map the jungle with space-shuttle radar He's also trying to help a friend find a pirate ship in Florida
—Peter Rondinone

"We know no more our own destiny than a tea leaf knows the destiny of the East India Company '
Douglas Adams

ZODIAC DISCRIMINATION

Your astrological sign could be keeping you from getting that job, according to Ralph Bastedo, a political scientist at the State University of New York at Stony Brook. "In fact," he says, "such discrimination is so common, it's been going on at of all places Ralph Nader's Public Citizen."

Though Nader's group claims to be the "watchdog of America," agency official Joan Claybrook admits that she likes to use the stars as a point of discussion in job interviews. For example, she explains, "If an applicant is Pisces, I mention that one of their characteristics is that they often go in two different directions, which leads to the question of whether they have this problem."

And Claybrook isn't alone. In a recent study, for instance, Bastedo found that Berkeley students suffered zodiac discrimination when seeking employment in the San Francisco Bay area. The students say that if they're a Taurus or Scorpio, employers just won't hire them. Bastedo reports, "Taurus is supposed to be lazy and dumb, Scorpio evil and manipulative. But when they choose signs with more favorable traits, like Aquarius, which supposedly indicates a genius on a never-ending quest for truth, they get the jobs."

Bastedo points out that those who use the zodiac to evaluate job seekers usually go undetected. These employers screen and reject job applicants in private, he says, and how many people ever suspect they were disqualified because of a birth date?

One would naturally expect Nader's watchdogs to put a bite into the practice of hiring on the basis of astrological sign. But when asked to comment, Clay brook's assistant, Phyllis McCarthy, said, "Joan just uses informal interviewing techniques, like we all do."

—Peter Rondinone

"The more details I can foresee, the more probabilities I have of saving my self."

Italo Calvino

MUSICAL HEARTTHROBS

While lying on his living-room couch and listening to music, a Minneapolis psychologist taught himself to beat his heart to the rhythms of jazz, country and rock and roll. He claims he can even produce two heartbeats for one musical beat, creating a percussion background.

The virtuoso (below, right) is Avi Yellin, forty-six, director of research at the University of Minnesota's child and adolescent psychiatry division. Yellin can synchronize his heart with a metronome clicking between 60 and 140 beats per minute, says colleague David Lykken, a psychophysiologist. He has done so in the lab for up to 40 minutes and at home for indefinite periods of time.

If one man can do it, other people as well should be able to influence heart rhythm and blood pressure, adds another colleague, University of Minnesota cardiologist Jay Cohn. Despite preliminary psychological tests, including measurement of brain waves, blood plasma, and blood pressure, Cohn does not yet understand the mechanisms by which Yellin voluntarily beats his heart. But, he says, with enough study he may be able to adapt the technique for widespread medical use. By administering nerve blockers to see whether they cause Yellin to lose his control, for instance, Cohn hopes to learn how certain medications affect the human nervous system.

Although Cohn doesn't understand this special skill, Yellin himself has a theory. He says he may be linking the brain's cortical areas, which direct higher functions, with subcortical regions, which control internal organs. "There might be a way," he suggests, "to instruct the cortex to communicate with an organ other than the brain, retrieve information, send it back to the cortex, and translate it into a language we can understand."

No special environment is needed, Yellin concludes. "I can do it even while driving a car."

—Connie Zweig

"If a table moves when no one is touching it, this is not obviously more likely to have been effected by my deceased grandfather than by myself. We cannot tell how I could move it but then we cannot tell how he could move it either."

F.W.H. Myers

ANIMAL WARFARE

Marian Bailey, director of Animal Behavior Enterprises in Hot Springs, Arkansas, surgically implanted 22 pounds of aluminum into the belly of a wild boar. But when the boar was revived, she observed, it couldn't jump a small fence without its stitches ripping open. Next time, Bailey vowed, the boar would be stuffed with less aluminum.

Sound like a day in the life of a neo-Nazi? Actually, Bailey has been paid by the Defense Department to find new ways to use animals in land warfare. "An animal that can withstand weighty implants could be stuffed with guns, ammunition, and secret documents, and then trained to cross enemy lines, undetected, like a Trojan horse," she explains, adding that animals were first used as implements in combat during World War II.

According to Bailey, behavioral psychologist B. F. Skinner was one of the first to work on animal warfare. He trained pigeons to expect food whenever they pecked at grids covered by pictures of gunboats. When they were later put into the nose cones of bombs and dropped over the real boats, the pigeons pecked at grids that sent the missiles sailing straight ahead, ensuring that the bombs (not to mention the unsuspecting pigeons) stayed on target.

Pigeon technology was expanded, Bailey explains, during the Vietnam War. During that era, she trained pigeons to fly over enemy lines. When they spotted a sniper in a tree, she says, they were taught to land nearby, thus changing the frequency coming from microtransmitters in their stomachs and warning U.S. troops of danger ahead. "Unfortunately," she adds, "we soon discovered the villagers were shooting our spies from the sky and eating them for lunch!"

Despite such setbacks, Bailey now foresees the day when killer whales are put on sentry duty along the Russian coast. By teaching the whales to follow the sound of submarines, she says, she could train them to pinpoint enemy vessels for our bombers. And there's also talk, Bailey indicates, of using monkeys to launch missiles from colonies on the moon. "But," she says, "I really can't discuss that. It's classified top secret."

—Peter Rondinone

"Everything summons us to death; nature, as if envious of the good she has done us, announces to us often and reminds us that she cannot leave us for long that bit of matter she lends us, which must not remain in the same hands, and which must eternally be in circulation; she needs it for other forms, she asks for it back for other works."

—Jacques-Bénigne Bossuet

AIRPORT FOR EXTRATERRESTRIALS

If extraterrestrials visit Earth sometime soon, where will they land? The White House lawn? The Grand Canyon? Perhaps the Kremlin? Better guess again.

A close encounter of the third kind will occur on the slope of Oriental Mountain, 80 miles south of Mexico City, claims Antonio Vazquez Alva, the man who is building an airport for extraterrestrials there. Alva, forty-four, is a faith healer and president of the occultist Mexican Futurology and Imagination group.

The airport, which is nearing completion, has a small landing field with a rainbow of signal lights and there is a modest terminal building where the extraterrestrials and humans can get to know one another. Alva was instructed to build the project, he claims, by an advance party of extraterrestrials from a world "in the fourth dimension."

"They look like humans," Alva says of the alien beings, "but are much more beautiful and shine like angels. Some of them are six feet tall," he adds, "and others are very small—only six inches high."

The extraterrestrials will land at the airport when it is complete, Alva asserts. "These are superior beings with a solution for peace on Earth," he adds, "and they will fulfill us in a way that religion has not."

—Eric Mishare

"The erection of artificial worlds in space is inevitable. Once man's breakthrough into space has begun, it will be as irreversible as the discovery, colonization, and exploitation of new countries during the age of great historical discoveries."

—Iosif Shklovsky

GUINEA PIGS

CONTINUED FROM PAGE 49

Northern fur seal has a particularly large and active pineal body a gland in the back of the brain. Although its function in humans is still unclear, it is thought that the pineal gland regulates reproductive hormones in response to levels of daylight. Keyes suspects that the seal's pineal body regulates the animal's growth and sexual activity, signaling when it is time to go ashore and start mating.

Keyes also believes that studying the fur seal's pineal may help us understand the somewhat subtler features of the same organ in humans. "Children display a growth pattern somewhat similar to fur seal pups' in that they grow faster in the spring and summer than in the fall and winter," he writes with C. Arthur Eiden and Charles E. Marshall in the *American Journal of Veterinary Research*. And as for our own mating season: "More babies are born in April than in other months—thus, more conceptions occur ten lunar months earlier (July) when daylight hours are the longest."

Another indication of human dependence on light cycles, says Keyes, is the low fertility rate among blind women. Many do not even menstruate. To remedy this, some blind women have been advised to sleep with the lights on during their expected time of ovulation to enhance their regularity.

Because of the nature of its brain and nervous system, one exotic animal, the octopus, has become increasingly popular.

"The brain of the octopus is among the best known of all animals—period," says Roger Hanlon, chief of the cephalopod biology section of the Marine Biomedical Institute at the University of Texas, in Galveston. (The cephalopods include octopuses, mollusks, cuttlefish, and squid.) Hanlon, who raises various species of octopuses for lab use, notes that the animal has two discrete areas in its brain for learning, one for visual stimuli, the other for taste and tactile stimuli. If the area for visual stimuli is removed, for example, the octopus can still learn such tactile tasks as how to choose a rough object.

Researchers studying the brain and nervous system of the octopus have discovered that this eight-armed creature learns in much the same way as we do. Explains zoologist Martin Wells, of Churchill College at Cambridge University, England: "Since we know that the individual nerves of mollusks have properties almost identical to those of vertebrates, the similarity at higher levels clearly implies that the two learning machines are identical or must at least share many structural features. Thus," he concludes, "if one understands how learning works in octopuses, one may well know how it operates in other animals."

According to Wells, octopuses are better models for studying learning than are the standard rats or monkeys because the structure of the octopus brain is completely different from that of vertebrates. The problem with using rats as models of human learning is that both the human and rat brain evolved from the same common ancestor. Thus it is difficult to tell by studying brain structure which parts developed as the result of learning and which parts are simply the vestiges of evolution. "But if we compare the structures associated with learning in the cephalopods with those found in vertebrates, our situation becomes more hopeful," writes Wells. "The two learning mechanisms have evolved quite independently.... It is unlikely that the two sorts of brain will be encumbered with the same irrelevant structures, so if we discover the same structural arrangements in the two learning machines, we have a good reason for supposing that learning depends upon this particular sort of arrangement."

For all their dissimilarities with vertebrates, some species of octopuses are like opossums in one respect: They are difficult to contain. "We have one species here that crawls out of just about anything," says Hanlon. "I've seen them squeeze through an opening one inch in diameter, and they have bodies at least five times that width. More than once I've walked down the halls

of the laboratory and met an octopus coming the other way."

One mystery that has fascinated researchers for years is the ability of some animals to hibernate. Now they are examining some of the amazing transformations the body experiences in this state. The hibernating 13-lined ground squirrel, for example, can use its extended nap to regenerate nerve tissue, even heal a severed spinal cord.

The squirrel's secret: During hibernation, scar tissue, which blocks nerve regeneration, does not form. "When any animal hibernates, its body temperature goes way down, and at such low temperatures, the body cannot make collagen, a major component of scars," says Lloyd Guth, chairman of the department of anatomy at the University of Maryland, in College Park. "At these cold temperatures all body systems slow down. The heart rate drops to one or two beats per minute, the breathing rate goes down, and wound healing does not occur. But nerve regeneration does continue, although slowly. When the nerve grows back in the area where it was cut, it detours around the wound instead of running through it. Over the several months that the 13-lined ground squirrel hibernates, Guth has observed substantial nerve regeneration."

Another hibernating animal being studied in the laboratories is the little brown bat. Researchers want to learn how it makes a unique adjustment in its reproductive cycle to the long sleep.

For most male mammals that breed in cycles, a rise in blood testosterone signals the start of mating season. The animal's body is already making sperm; its secondary sex glands mature, and the animal goes out and mates. At the beginning of its cycle the little brown bat also experiences a spectacular rise in testosterone—to levels 10 times higher than in men and bulls, 20 times higher than in stallions, and 30 times higher than in rabbits.

But the little brown bat must synchronize sperm release with the maturation of its sex organs. Because all that testosterone would cause its sex glands to mature too early, the bat's body releases a sex-steroid binding protein to tie up the excess. The protein keeps sex glands from maturing before the sperm is ready. Once the sperm production is well under way, the level of sex steroid binding protein falls off, allowing the testosterone to ready secondary sex glands like the prostate.

Come September the whole process is complete, and the bats usually mate before hibernation. If the bats do not mate before the big sleep, however, there is no problem. They are quite capable of storing their sperm for great lengths of time. The bats can still mate during the winter or in the spring.

Scientists David Damassa and Alvard Gustafson, of Tufts University, study the little brown bat to try to figure out why the animal's cycle works this way. "The sex-

steroid binding protein seems to act as a buffer, as a reservoir for the excess circulating testosterone," Gustafson says. "There are many species that have blood proteins that bind to sex hormones, but the only mammal we know of with sex-hormone binding proteins similar to man's and other primates is the bat." From these analyses of the way the little brown bat copes with hormones, new ways might be found to treat humans who suffer from prostate-gland diseases, which are thought to result from imbalances.

Like the bat, there are a number of animals that have been singled out for study of specific illnesses that plague man. Snakes, for example, are the unsung heroes in the battle against kidney stones and gout. According to William Dantzler, a physiologist at the University of Arizona, in Tucson, who does his research with the common garter snake, snakes have specialized kidney cells, called nephrons, that remove uric acid from the kidneys. Improper uric acid metabolism is behind both kidney stones and gout.

Humans also have nephrons, but the snake's can be easily separated from the kidneys and will continue to function outside the animal. With snake nephrons, says Dantzler, "we are developing a better understanding of how the kidney regulates the excretion of uric acid." Once that is deciphered, the next step would be to develop therapies for enhancing the excretion of uric acid in gout victims and for reducing the formation of kidney stones.

Snakes are newcomers to the lab, but woodchucks (groundhogs) have long been used in the lab for studying such phenomena as hibernation and obesity. Now they are also part of the fight against the human hepatitis-B virus. Woodchucks naturally get infected with a virus similar to the human hepatitis-B strain and as such are ideal animals for mass-testing new hepatitis vaccines. With this goal in mind, Bud Tennant, professor of comparative gastroenterology at the New York State College of Veterinary Medicine at Cornell University, in Ithaca, and his colleagues are trying to start breeding a colony of chucks that are disease-free and whose genetic background is known. "There has never been a source of woodchucks suitable for the intensive kinds of research now being proposed," he says. "We hope to change that."

Woodchucks are also ideal for the study of a related disease, cancer of the liver. In humans, hepatitis-B is a risk factor for this cancer—chronic carriers of the hepatitis-B virus are about 250 times more vulnerable to liver cancer than noncarriers. "Because the virus appears to be a risk factor," explains Tennant, "it makes sense to assume that if you prevent hepatitis-B, you could remarkably reduce the incidence of liver cancer."

Some animals are particularly valuable in cases of very rare human diseases for which data are meager because the illness strikes only a tiny portion of the population. One such disease is Severe Combined Immune Deficiency Disease (SCID), a genetic disorder that is rare—it afflicts only one in 600,000 children at birth—but deadly. Its victims have little or no immune resistance to infection or disease. To survive, SCID children must live their entire lives inside sterile plastic bubbles to shield them from microbes that are innocuous to most people but fatal to them.

"Because so few children are born with the disease, there aren't many cases to study," says Nancy Magnuson, assistant professor of veterinary microbiology and pathology at Washington State University, in Pullman. "Obviously the parents are very upset and don't want a lot of scientists around poking the child to get blood samples. So we breed Arabian horses to study the disease."

Like humans, horses are protected by their mothers' antibodies for a brief period after birth. "It's difficult to believe that they are sick at all," observes Magnuson, "because they look and act healthy when they are born. But within sixty minutes of birth, we can test them to tell whether they have SCID or not. And once the mother's antibodies degrade, the horses begin to get infections."

Like SCID children, the horses must be completely isolated. Keeping them in sterile bubbles is too expensive, so they are kept in a sterile barn. Only a few people are allowed to work with them, and everyone must wear clothing that has been disinfected. Horses cannot contract human diseases, but a human can carry a disease from horse to horse. Even after all these precautions, the horses are usually dead within six months.

To keep the animals alive even for that time, researchers inject healthy fetal thymus and liver cells into the horses' abdomens to give them some resistance. Healthy *fetal* cells are used because these cells have not yet developed immunities and thus will not reject the SCID horses' tissue. Notes Magnuson, "We are hoping to solve the problem in the horses so that we may help children with the disease."

In the future our relationships with animals, scientific and otherwise, no doubt will continue to bloom. Almost 200 years ago, in the original paper on his smallpox vaccine, Edward Jenner described the nature of the bargain we have struck with animals: "From the love of splendor, from the indulgence of luxury, and from his fondness of amusement," he wrote, "[man] has familiarized himself with a great number of animals, which may not originally have been intended for his associates. The wolf, disarmed of ferocity, is now pillowed in the lady's lap. The cat, the little tiger of our island, whose natural home is the forest, is equally domesticated and caressed. The cow, the hog, the sheep, and the horses are all, for a variety of purposes, brought under his care and dominion." DO

HAD DESCARTES LIVED DURING THE PHYSICAL FITNESS CRAZE.

ASTROVIDEO

CONTINUED FROM PAGE 52

higher electric potential act as electric barriers between the wells. Each well corresponds to one pixel, the single dot of light that is a video screen's basic image unit. The number of electrons going into each well depends on the brightness of the portion of the observed galaxy it is "reading." Thus, the electrons collecting in the CCD's wells are translated into a digital representation of the observed galaxy. Wells containing few electrons represent darker areas of the galaxy, wells with many electrons represent brighter areas. Once the chip is exposed, it is necessary only to count the number of electrons in each well—its electric charge—to build up a pixel-by-pixel image of the galaxy upon which the telescope is focused.

For astronomers, the CCD's little electrons are a big bonanza. Virtually anything film can do, they can do better.

"Film looks bright and shiny because it's bouncing away most of the light that hits it," says Latham. "A CCD array looks dark because it's absorbing most of the light—it's much more sensitive."

At their best, photographic emulsions will record no more than 3 percent of the photons striking them. CCDs, by contrast, have efficiencies of about 70 percent. Equip an ordinary telescope with such technological wizardry, and it will outperform even the giant reflector at Mount Palomar. And jumbo telescopes beefed up with CCDs, become superpowerful. In addition, while film can see about 100 tones of gray, CCDs are sensitive to nearly 10,000 tones.

"With electronics, every telescope ever made is more powerful," declares Latham.

All this new power has a bonus: speed. Projects that took weeks with photography because of the long exposures needed might take only hours with electronics. That is a godsend with good telescopes so scarce, astronomers must elbow and knee their way into the observatories. Important projects get trampled in the competition. With CCDs, however, even mothballed telescopes too weak for modern work, suddenly become useful again.

On clear nights, for instance, Latham puts on his motorcycle helmet and roars 40 miles out of Cambridge to a Boston suburb. Latham, a trim man who could pass for a stockbroker, is a former dirt bike racer. But these motorcycle runs are strictly for science. He visits an old 90-pound weakling of an observatory to study the universe's lumpiness.

Latham and his colleagues are probing the distribution of galaxies in space using spectroscopy to fan out the light from each star complex into its wavelengths. Analyzing such spectra, they glean information ranging from a galaxy's temperature to the direction in which it is moving.

Movement, for example, shifts a star's light toward one end of the spectrum or the other, depending on its direction. If a star is approaching, we perceive its speed added to the speed of its incoming light wave. Consequently, more waves seem to reach our eyes each second, shifting the star's light toward the high-frequency (violet) end of the spectrum. In the case of a receding star on the other hand, its speed is perceived as subtracted from the speed of its incoming light waves. Fewer light waves reach our eyes each second, shifting the star's light toward the low-frequency (red) end of the spectrum.

Such spectral information from several thousand galaxies is now stored in the Harvard-Smithsonian Center's computers, and it has revealed that the universe's matter is distributed anything but smoothly. "We've found long strings and big clumps of galaxies, interspersed with great holes where there is nothing," says Latham.

At first glance, it would seem that it indeed the universe began with a Big Bang, as many cosmologists now believe, the primordial explosion would have sent matter whizzing out evenly in all directions. But Latham says the force predisposing the universe toward lumpiness is gravity, acting over the aeons to pull larger chunks of

matter together. "I think the universe will expand forever and gravity will lose," he says. "But here and there gravity wins, clustering galaxies together."

Latham's group is conducting its survey, a major exploration of the skies, using an outmoded telescope that electronic technology has given a new lease on life. "We can use it for about fifteen dollars a night," says Latham. "That's quite a saving compared to five thousand dollars nightly for the telescope the Harvard-Smithsonian astronomers usually use at the Whipple Observatory in Arizona. Moreover, we're seeing millions of light-years farther than if was possible to see just ten years ago."

CCDs are giving optical astronomers like Latham sharp new eyes with which to study the visible light streaming in from the stars. But the Electronic Age offers astronomers yet another gift—image processing. Whether they work in the visible spectrum or the nonvisible radio, X-ray, ultraviolet, and infrared range, image processing offers them powerful new methods for manipulating data from the sky.

For instance, astronomer Christine Jones shares a suite of offices at the Harvard-Smithsonian Center with her astronomer husband, William; their tan-and-white fluff ball of a dog; and stacks of magnetic tape containing data transmitted to Earth from the *Einstein* satellite. The boxcar-size orbiting observatory which scanned the universe with X-ray eyes, is now dead. But Christine Jones and other X-ray astronomers are still working through the miles of taped data it transmitted. Her key tool is the center's high-tech *pièce de resistance*, the Image Processing Facility.

EINSTEIN IMAGE PROCESSOR appears on a display screen as Christine Jones, working at one of a dozen terminals in a computing room at the sprawling Harvard-Smithsonian complex, logs in to the system on a recent afternoon. She presses more buttons, and up on the screen floats an image that might be a blue frying pan covered with greenish olive oil in which scrambled eggs are cooking, topped with catsup. Actually, it is a processed X-ray image of a supernova remnant, all that is left of an exploded star.

"This probably went off around 1600," says Jones, noting that the image's colors are arbitrary, coded to represent different X-ray intensities given off by different areas of the remnant. "The brightest areas are white, then red, then green, and so on."

Jones is working out the physics of supernovas, a field that is particularly interesting because astrophysicists believe most of the material in the universe was manufactured in such stellar blast furnaces. The image on the screen is of Cassiopeia A, a typical supernova remnant discovered in 1948 as a radio source but not detected as an X-ray source until a 1967 rocket flight. Jones pushes buttons, and the image shifts, now graphically displaying the elements dominating various regions of the remnant: hydrogen and helium around the outside perimeter, then silicon, sulfur, and on through a whole chemistry set of increasingly heavy elements toward the remnant's center.

"You see things differently in X rays," she says. "In fact, you see some things you can't see at all in the optical or radio bands." As one example she cites hot gases—30 million degrees Kelvin—stretching between clustered galaxies as well as surrounding isolated galaxies as coronas. "Neutron stars and black holes can also be surrounded by disks of hot gas, visible only in X rays," she says, punching a new code number into the computer.

Up on the screen comes a new picture, seemingly made of tiny abutting boxes, a mosaic of another supernova remnant that the image processor has pieced together from hundreds of separate bits of X-ray information. The optical telescope saw nothing special inside this remnant, but the X-ray satellite detected a pulsar, a star that generates bursts of radiation at regular intervals. Jones points to a spot on the screen. "See that little white dot? The pulsar's that guy."

Now she steers the image processor on a tour of the universe, zeroing in first on an immense shoal of stars, a cluster of hun-

"Don't worry, Mrs. Parker. We'll have your problems solved in no time."

dreds of thousands of galaxies, swimming in a sea of superhot gas. "We're working on these cluster galaxies because it's not clear whether the galaxies form from the gas or whether they form separately and then group together," she says, adding that the picture on the screen is an optical image of the cluster.

At the press of a button the image shifts, becoming a burst of colors, the same cluster of galaxies seen in the X-ray range. "Now you can see that what looked like empty regions in the optical image are actually full of hot gas emitting X rays," says Jones. With the image processor, she notes, astronomers can do studies that otherwise would be extremely difficult and time-consuming, even impossible. For example, one elliptical galaxy seemed to be a strong X-ray source. But under high resolution in the processor, it turned out that the actual source of the X-ray emissions was two quasars, immensely energetic and mysterious stellar objects, one on each side of the galaxy. "That was a great surprise to us," she recalls.

The on-screen interstellar tour continues. Up floats a young galactic cluster, a green fried egg with two red yolks. The yolks are dense clusters of stars within the larger formation, 3 million light-years apart. "They're special kinds of galaxies that grow by cannibalism, ingesting nearby galaxies over hundreds of millions of years," says Jones. Then the *Millennium Falcon* hyper-drives to another corner of the universe, cruising toward one galaxy that trails a big X-ray plume. This galaxy, she says, seems to oscillate back and forth through the cluster, taking 5 billion years for each cross-cluster journey. "The X rays show you the dynamics of these processes, and the image processor lets you see what is happening," she says.

According to a colleague of Jones's, radio astronomer Dan Harris, the electronic revolution really began after World War II with the advent of the huge metal ears that tune in the universe's radio crackles and hisses. "Those first radio astronomers were radar and electrical engineers interested as much in technology as in science," says Harris, a bearded man in shorts and sneakers. On his office shelf he has what seems astronomy's requisite apparatus: a motorcycle helmet. He points out that because radio waves produce no images, radio astronomers long ago learned to construct images by crunching data in a computer—electronic astronomy's central activity. But the new image-processing equipment, like the system he uses at the Harvard-Smithsonian Center, stands in a different league.

"My main joy with that machine is putting together radio, optical, and X-ray images in one picture," he says.

From the heap on his desk, Harris fishes out a picture made on the image processor, a cluster galaxy called the Jet/Tail Galaxy in A75A. The image is composed of thousands of red dots, each an entire gal-

axy Spreading out behind the cluster is an enormous, green plume as it some mad geneticist had forced a tiny field mouse to sprout the immense tail of a collie The cluster is an optical image and the green tail is formed by electrons speeding at near light velocity and spiraling in a magnetic field so that they emit radiation in the radio range,' says Harris 'What are that emission's physics? Images like this can help us find out.'

He deals out another picture of the cluster this one polarized "That shows us the magnetic field isn't tangled and twisted " he says 'But we still don't know if the tail is being jetted out or if it appeared because the galaxy is moving through gas All we can tell at this point is that the radio tail is produced by electrons traveling at the speed of light ' He ponders the picture, brow wrinkled It's a frustrating field, but the point is, the image-processing device is useful for putting various kinds of information together Five years ago it would have been difficult to do this work

Astronomers throughout the Harvard-Smithsonian Center's sprawling hodgepodge of concrete-and-glass modern and Fifties brick can screen the computer-processed images on remote terminals But the operation's heart is the Image Processing Facility itself down a dark corridor and through an inconspicuous door Inside it looks like a high-tech theater Thickly curtained, the room has three walls lined with six computer screens and a jumble of central processors printers and video cameras On a recent afternoon an astronomer was slouched in one of the room's plush chairs and was staring gloomily at wavy blue lines on one screen Strewn across a table were prints astronomers had made of their work—one showed a red globe expectorating a blue stream with a pulsing white heart as if a cannibalistic cluster had found a smaller galaxy too sour to swallow Beside it was a print of another galaxy, shading from dense white at its core to the most delicate violet at its perimeters against the blackness of space

'Pretend you're a galaxy says Tom Stephenson, the young soft-spoken physicist who designed the facility He focuses a video camera on a visitor's face Moments later it materializes on one screen—a rather startled-looking galaxy We'll use that image to show some of the things the equipment can do, Stephenson explains fiddling with controls

On the screen the visitor's face abruptly freezes The screen splits one side showing contour lines mapping the brightnesses across the image Stephenson slides the contour map over the face—if it were a galaxy astronomers would be seeing a graphic rendering of its structure He makes the face do a weird dance, changing colors becoming cartoonlike, breaking into particles each image a different way of analyzing the object On a separate screen rows of numbers begin marching in phalanx That's giving a numerical readout of luminosities on the image says Stephenson An astronomer studying some object out in space can get an immediate printout of how many photons fell on a particular part of the CCD connected to the telescope, a precise measure of the radiation from one region on the object he's observing '

By changing and intensifying colors an astronomer can highlight certain features he wishes to study He can draw a line through the image on the screen and graph luminosities at each point along the line He can superimpose four images of one object to intensify faint features He can count photons emanating from a particular area He can also do "image arithmetic"

"Watch this " Stephenson says as he turns the visitor's face into a facsimile of Han Solo's visage at the beginning of *Return of the Jedi*, when the intrepid space skipper had been converted into a bas-relief wall mural The effect, Stephenson

> *My main joy with the image processor is that it combines radio, optical, and X-ray images of the universe so that you can see things that were invisible before*

explains is created by superimposing two images of the same subject, slightly displaced and then subtracting one from the other The result is an 'edge enhanced' image that emphasizes structure Applied to a galaxy the technique produces an image that looks like a scale model of the Himalayas showing the structure of each star and the galaxy as a whole Stars are densest where the peaks are highest

You might add together two images made at different times of an object—like the expanding Crab Nebula ' Stephenson says 'The dark features will be areas that haven't changed and the bright features will be areas where the nebula has grown

He summons onto the screen a picture of M87, a bright galaxy at the heart of the Virgo cluster that is spewing out a jet of plasma (See the larger of the two photos on page 51) 'We wanted to know if the jet extends all the way to the galactic core ' he says adding that the jet's path inside the galaxy was obscured by the radiation from the densely packed stars To settle the issue Stephenson flipped the image of the galaxy so that the jet shot out the other side, superimposed the new image over the original and subtracted one from the other The main body of the galaxy its matter more or less evenly distributed canceled itself out What was left was the line of the jet issuing from the core

Such image-processing techniques coupled with CCDs, can produce virtual motion pictures in living color Astronomer Rudy Schild who is a pioneer in CCD astronomy says 'We could never produce these true color pictures of galaxies with chemical emulsions

For optical astronomers colors reveal data about the temperatures and structure of a galaxy 'You might infer it from numerical measurements but the picture shows you things you wouldn't have thought to ask ' Schild explains, producing a CCD picture of a spiral galaxy and pointing to a blue dusting at the top and bottom 'That must be a very young star-forming region he says Pointing to a brown smudge in one portion of the galaxy he adds 'That seems to be a dust cloud here in this area of older stars which is surprising because we associate these clouds with younger stars So one question we'd like to answer is Why aren't there any younger stars here?'

Schild is trying to understand how galaxies originally formed he is probing back toward the origins of the universe And he says that the new electronic technologies coupled with the unified-field theories that high-energy physicists are now working out are gradually giving astronomers a new view of the cosmos It is a creation almost beyond understanding

'It now seems likely that ours is not the only universe he says 'But even if we could visit other universes they might be totally incomprehensible

Electrons in another universe if they exist at all, might have a mass different from the mass of electrons in our universe he says The speed of light might be different too making matter and radiation there beyond our imagination 'We could never communicate with them but the prospect of other universes raises vast philosophical implications—for instance is another universe heaven?

Four times a year Schild flies out to the Smithsonian Institution's Whipple Observatory in Arizona, and rides an all-terrain vehicle up the rugged mountainside to reach the observatory perched on top like a Tibetan lamasery Then he spends a week or two at the telescope taking electronic snapshots of galaxies so far away the light reaching us now began its journey when our universe was only a baby He returns to Cambridge with miles of magnetic tape packed in a carton

Someday he says, with the advent of satellite links and fiberoptic cables astronomers may not visit observatories at all They will direct the telescopes remotely storing incoming data in their office computers They will need to look at the sky only to check whether to put on a raincoat before motorcycling to work ⌧

FAST FILMS

BREAKTHROUGHS

By Phoebe Hoban

In the movie *Brainstorm*, two scientists create a Walkman-style headset unlike any other It records reality A holographic tape captures a complete event and allows others to experience it again Characters in the film relive such hair-raising episodes as a van plunging over a precipice into the sea, a stomach-jolting roller-coaster ride a race car speeding past the finish line and even the ultimate experience—death Shot in 70mm, such scenes were dramatic enough to have most of the audience clutching their seats But *Brainstorm*'s director Douglas Trumbull says the movie's spectacular effects barely scratch the celluloid surface of what s possible If it had been filmed in Showscan the audience might have fled the theater early emotionally exhausted

Showscan is Trumbull's brainstorm for a revolutionary new form of entertainment Known for years as one of Hollywood s technical wizards—he masterminded special effects for *2001*, *Close Encounters of the Third Kind* and *Blade Runner*—Trumbull came up with the idea as he viewed segments of *2001* at very high speed He noticed that the accelerated frame rate caused an unusual "live video" effect After experimenting with shooting and projecting 16mm film at a variety of speeds Trumbull found that at 60 frames per second the viewer suddenly perceived the action superrealistically A conventional shot (filmed and projected at 24 frames per second) of a golf pro teeing off reveals a flurry of motion then a blurred image as the ball vanishes in the distance At 60 frames per second the viewer can distinctly see the ball as it leaves the tee and flies through the air until it passes entirely out of the frame

Trumbull s next two experiments were action shorts shot in 70mm at 60 frames per second For one the camera was mounted on a roller coaster, for the other it was placed on a car taking hairpin curves on a mountain road Screened at 60 frames per second by a group of unsuspecting California college students, the films provoked definite responses A team of local doctors monitoring the audience detected a jump in heart rates and galvanic skin responses far exceeding the normal level

"People reported a disconcerting feeling of voyeurism Trumbull says 'The enhanced illusion of reality is the most important aspect of the process Showscan technique greatly increases the three-dimensionality color saturation, light dark and detail of film It makes the movie screen more real than life But Showscan has another interesting side effect It appears to alter people s perception of time Because they are seeing so much more motion packed into each second, a ten-minute film seems to stretch to half an hour

'The experience is so powerful frightening and tiring, says Trumbull that people can't believe they could physically withstand a full-length feature film So we realize we've come up with a totally new medium It s not TV and it s not motion pictures—it s something else As a result future Showscan films may be considerably shorter than today s movies

Trumbull has joined with Brock Hotel Corporation to build state-of-the-art theaters that will include souped-up sound systems (five stereophonic channels) and deeply curved wraparound screens that will give the audience a 90° horizontal view—four times wider than usual The square 100 seat theaters will also be specially angled for an unobstructed view of the screen The first three test theaters are now being built in Huntsville Alabama Springfield Missouri, and Dallas with premieres planned for early this year

The main reason major motion-picture studios haven t jumped on the Showscan bandwagon is expense It costs up to 10 percent more to shoot a film in Showscan In addition studios are reluctant to use a process that requires building totally new theaters equipped with specially modified cameras and projectors But Trumbull is hoping directors like Steven Spielberg and George Lucas will capitalize on the new possibilities Showscan offers them Spielberg at least, has been impressed "I like to think of it as Trumbull-vision he says "It can turn the mundane into the event"

NEW PRODUCTS

What s the fairest on the wall?—a bathroom mirror that never steams up A British company has developed an illuminated 30" × 20" mirror equipped with a humidity sensor When the humidity reaches a preset level the mirror s circuits automatically activate a heating element behind the looking glass to prevent it from fogging up (Electric Mirror Company Ltd 335–339 Latimer Road London W10 6RA, England)

A TV that takes pictures of itself is currently being marketed in Japan by the Mitsubishi Corporation The digital television set comes with an added button that when pushed, signals a built-in thermal printer to generate a black-and-white print of any scene on the screen ($1 050 from Mitsubishi Electric Corporation 2–3 Marunouchi 2-Chome Chiyoda-ku Tokyo 100, Japan)

INTERVIEW

CONTINUED FROM PAGE 66

ously because it looked like reality

Omni: Did that mean you found there were longer droughts or more discharges than expected, for example?

Mandelbrot: Compared with earlier models mine implied much longer droughts or floods, the kind of zigzagging fluctuations that make dams fail to perform their assigned task because too often they are either full or empty. In Egypt the lengths of droughts are not limited to short time spans (like the reign of a pharaoh or the term of office of his chief minister) but often extend to the total length of a dynasty—millennium-length fluctuations. If you look at a record of the Nile's discharges, you don't see little flags that mark the beginning or the end of a drought. Each record seems to look like random noise superimposed on a background that is also noisy. The background seems cyclic, but you can't extrapolate from its cycles for predictive purposes. They are not periodic. This is why dams for long-term water storage are so hard to design.

Omni: There was no long-term average that all the Nile data converged upon?

Mandelbrot: No. The records look like a hierarchy of random noise on random noise. We showed our collection of graphs to a small group of hydrologists. We mixed up unlabeled graphs of the actual records of the Nile and some other rivers with graphs drawn either from my model or from the modifications of my model or from the models that hydrologists had tried previously. We challenged a particularly famous hydrologist to distinguish the real data from the fake ones. He immediately dismissed the graphs made from the old models, saying, "Rivers just do not act like that." But he failed to distinguish the real graphs from those drawn by my models, even after we read the labels on the back and told him which were the real ones.

That was a revelation to me. Before that I could not persuade people to consider the crazy mathematical idea behind my model. But after the expert acknowledged that my model showed riverlike behavior, I realized that the power of the eye to discriminate shapes was much greater than anticipated. This was extraordinarily pleasurable, because I am almost completely visual. I can hardly count, but I know how to recognize shapes by their shape, not by mathematical formulas.

Omni: Didn't this research lead into economics, where experts like to break down stock or commodities data into a trend, a few cycles, and noise?

Mandelbrot: That's another chapter of my checkered career. To the contrary, I didn't start dabbling with the Nile until I had already stopped work on my model of stock-market prices and prices of such commodities as cotton. Later on, impressed by the power of persuasion of my hydrological fakes, some people at Bell Labs performed a similar double-blind test on my stock-market fakes. They took my formula and used it to generate some artificial price charts. Then they generated further charts after they had deformed my model by deliberately changing an important number. Finally someone showed the resulting mixed batch to an eminent stockbroker and challenged him to prove he knew his business and could identify the real thing among the imitations. He had no hesitancy in picking the charts drawn by my model. He rejected all the others as being "too smooth or too unsmooth." The real thing is in between," he said. "Its special nature is very subtle, but I can recognize real charts when I see them."

I had identified the particular feature of reality that makes stock-market charts look the way they look. My model could fake charts of either high or low volatility. The stockbroker had a clear visual impression of what charts should look like, because stockbrokers spend their lives looking at these things. Anyone who could fool him had to be doing something right.

Omni: How did you move from graphs to modeling physical shapes?

Mandelbrot: Graphs were never more than a second best. Soon after my work on the Nile and on cotton, I wrote a paper on the geometric shape of coastlines. Again this was a response to a challenge, namely to account for some obscure observations of a visionary English scientist, Lewis Fry Richardson. A real coastline is of course never circular; most are very wiggly. But not every wiggly curve looks like a coastline. What is the special property that makes some wiggly curves look like coastlines and others not? Richardson had pointed out that if you try to measure a coastline length with increasing precision, you must take into account increasingly small bays and promontories, and that, as a result, the measured length is bound to increase. A curve may not have a true absolute length, only relative lengths that depend on the method of measurement! Again, I was successful in identifying the proper mathematical trick that allows this strange thing to happen to curves and allows the degree of wiggliness of a curve to be measured objectively, just the way that temperature measures the degree of heat by one number. This number later came to be called fractal dimension.

My paper came out in *Science* under the title "How Long is the Coast of Britain?" It was okay, but it did not satisfy me. It was too abstract, too much in the style of meter readings. I wanted to obtain a gut feeling for the shape of coastlines and decided to find ways of performing forgeries. I thought up a suitable equation, and in 1973 we rigged up a very clumsy plotter to produce artificial coastlines. They were much harder to draw than graphs of the Nile. Sometimes we had to sit up all night with the plotters. But when the first coastline finally came out we were all amazed. It looked just like

New Zealand! Here was an elongated island there a squarish one and off to one side two specks resembling Bounty Island. Next time we got different islands

When we put smaller parameters in the same equation the shapes became smoother and rounder First they formed blobs like Taiwan, and eventually they became so regular that everyone would say "No real island can be *that* round" When we increased the parameters the coastlines became increasingly irregular and soon broke up into complicated archipelagoes, like the Aegean then like the Aegean as modified for science fiction purposes with even more tiny islets But in the right range of the parameters we got shapes typical of real islands and continents Seeing them had an electrifying effect on everyone The parameter in this equation is also called fractal dimension, and at last people understood what I meant by this term The idea had been around for a while but had remained abstract hence elusive Now after seeing the coastline pictures everyone agreed with me that fractals were part of the stuff of nature

Omni What was the role of computer graphics in your investigation of fractals?

Mandelbrot The theory of fractals had started in my mind before I knew it was to become a theory and well before I thought of computer graphics But without the proofs made possible by graphics the theory would have moved very slowly or may not have moved at all But in 1974 we found a computer graphics device that we knew might be able to draw artificial mountains Again the device was very cumbersome, but when the shapes came out, what a revelation! The pictures were poor black and white and drawn on coarse grids Shadowing was not feasible But even so there was a feeling that what we had drawn was right Even though the pictures looked old-fashioned like old worn photographs they looked like mountains There was no way anybody looking at them could say I was barking up the wrong tree Their eyes convinced them Since then of course, we have gotten better equipment and the last figures by [IBM's Richard] Voss are stunning It seems that we win all the computer-graphics contests

Before, people would run a mile from my papers but they could not run from my pictures At the beginning I used the graphics purely for this reason—to illustrate my ideas and to force people to accept them But I soon realized that by this method, I was able to go further and to integrate into a single theory a collection of things that otherwise would have seemed unrelated Now very complex geometric shapes could be compared with one another and with reality The equations behind the shapes were abstract but the shapes themselves looked live

Omni What is the difference between the meter-reading kind of science and the fractal kind?

Mandelbrot By meter reading you refer to the reduction of shapes to numbers and to measurements This is a universal trick in science and a very successful one in physics This trick however has been enormously impoverishing Traditionally scientists have looked at things with diverse features but have simplified the whole mess They say, for example All right we're not interested in the smell or color of this gas only its temperature and pressure ' This approach has worked extraordinarily well in many cases Physics and the few other mature successful branches of science are precisely those in which that approach has worked But what we are left with—and what I attached myself to first by accident and then with enthusiasm—are the phenomena for which that abstraction has not worked well If water resources had been as simple to understand as gas had then by 1965 water management would have been well in hand

Science had ignored a large residuum of phenomena in which many factors are mixed together and can t easily be separated These involve some of the most interesting and natural questions Children do not ask themselves about the temperature of a gas or about collisions between atoms They wonder about the shapes of trees clouds and lightning These questions are among the hardest Physics just left them aside but I tackled them The delight is that my fractal geometry has answered many such questions in a single swoop—over many years It involves extracting something interesting about coastlines clouds and lunar craters

Omni But do these ideas *explain* shapes or do they just let you create similar shapes? If your model of the Nile does not include rainfall silt or drainage basins are you not just doing what scientists call curve-fitting—tinkering with the equation until the line runs through the data points?

Mandelbrot You are needling me You know very well that the term *curve fitting* has many bad connotations I share the feeling that there is nothing good to say about those who would curve-fit each phenomenon separately, only to be left with a grab bag of unrelated and conflicting equations On the other hand there is a view which is very extreme that the whole of science is a search not for understanding but for one big equation that has relatively few parameters and can be curve-fitted to account in one swoop for many seemingly unrelated phenomena I am not defending this as being a completely satisfactory description of science But there is some truth to the notion that science is a search for a small number of central ideas that describe how various parts of nature fit together Fractal geometry faithfully follows this approach It centers on several very powerful principles that tell us how the world is put together

When you look at the traditional approach you see that physicists have been careful to seek out problems they could solve by reducing them to accepted prin-

ciples. But many other scientists have allowed themselves to set heroic if not hopeless tasks. Before they can say what a cloud's shape is, meteorologists want to know how varying the humidity affects the shape of clouds. In fact, they often cease to think of a cloud as a shape only as one or a few numbers extracted from observations. Physics should have taught us all that in the search for an explanatory theory, it is awfully convenient to start with a descriptive theory.

Omni: What about turbulence, which is notorious for being difficult to measure?

Mandelbrot: Turbulence was perhaps the greatest thorn in the flesh of certain areas of nineteenth-century physics. It was very irritating that turbulent motions of fluids should be so incomprehensible, whereas the other motions of fluids were easily understood. And it went on being ill understood. But by using a certain kind of scaling and fractal argument from other contexts, I put forward a bold conjecture about the nature of turbulence. Originally it was quite abstract, but it gradually became the most concrete thing imaginable.

Omni: What was your idea?

Mandelbrot: I conjectured that turbulence might be like the wind. The wind does not blow regularly but comes in bursts, each one divisible into finer bursts. In due time this led me to think that turbulent activity does not spread all over space but concentrates upon a fractal shape of a complicated but well-specified kind. The reason people had not thought of that possibility is that they didn't know that fractals existed. Let me take that back: some people knew vaguely but were convinced that these were abstract shapes no one could encounter in the hard world outside.

Omni: Would fractals be useful in studying pollution, where traditional methods give an average pollution level or assign a probable level of concentration in an area?

Mandelbrot: For something distributed by turbulence in wind or water, the average is totally meaningless. If the average pollution is very low but concentrated in a very patchy fashion and it hits you, it kills you. There are measures of dispersion, but one tends to disregard the "special case" by saying, "Of course there's a lump of the stuff here, but it's a special lump. I'm just going to eliminate it from the measurements." One censors the data. Or if something has a fairly high average of toxicity but a low lumpiness, so that it seems smooth, it may appear bearable. What the fractals give instead is a natural measure of lumpiness—lumpiness measured not by numbers or in books. Fractals are a measure on the basis of how things are. It is repeatable, whereas *ad hoc* measures of lumpiness tend to vary badly. If you know this lumpiness, you can begin to see the effects of willful action. In the matter of pollution, you can say that if the pollution is untouchable, there may be some cheap way of making it spread uniformly. Dilution is the solution to pollution. Natural phenomena may overtake it and make it vanish. Better not to dump it at all, of course. The fractal dimension would be a natural measure of the lumpiness of pollutants.

Omni: Still, a fractal model seems abstract. Do scientists resist it?

Mandelbrot: Many did and still do. When I studied the long series of cotton prices, for example, my fractal model was able to match the important upward and downward jumps in the historical record. Economists, however, kept telling me that to follow just one price series was not ambitious enough, that the only interesting thing for them to do was to seek ways to influence prices and to incorporate them into more complicated theories of demand and consumption. It was an uphill fight to convince people that my model did not compete with the giant econometric models running to hundreds of series. The giant models tried to do everything at the same time and hoped for results a bit better than those achieved by tossing a coin.

"If average pollution is very low but concentrated in a patchy fashion and it hits you, it kills you. Or if something has a fairly high toxicity but a low lumpiness, it may be bearable."

Omni: Was the resistance caused by just plain stubbornness?

Mandelbrot: No. I never thought it was pigheadedness or stupidity. The economists recognized that my methods implied a departure, and it is right that departures should be criticized sternly. One economist proclaimed that if I were correct, "it would indeed create a very difficult situation in economic statistics." The critics were being shrewd and perfectly correct.

Omni: But was it an article of faith that someday explanatory mechanistic theory would expand enough to encompass complicated irregular phenomena?

Mandelbrot: Yes, but in many cases it has not expanded. I do not deny theory. In fact, *I love theory*. But what do you do while a theory is slow in developing? I was proposing a qualitatively different kind of science in which the description of the phenomenon is an important question in itself. My persistence has been rewarded. As soon as a good description became available, many fields started moving on to excellent theories, sometimes due to my hand, more often to the hand of specialists I had drafted into my camp.

Omni: Your model for the distribution of galaxies is changing our ideas about the universe. Using fractal geometry, astrophysicists have shown that the larger the volume of space, the smaller the density of matter in it, and that stars cluster into galaxies, clusters of galaxies form megagalaxies, *ad infinitum*. How did you get started on this model?

Mandelbrot: Again, it began with a challenge brought to me by a friend. I developed an early model of the galaxies to account for some bizarre observations about the nonuniformity of the universe. For a time there were no suitable mathematical tools to represent the clustering of galaxies, and the more one knew about space, the harder it became to formulate such a model. But my equations, which take just a few lines to write, provide amazingly realistic models of the sky. They are becoming widely accepted.

Omni: They look right to the eye?

Mandelbrot: The eye is attuned to texture. But there is no ready-made theory of texture. In all these cases the eye was much more effective than meter readings, which were trying to tell us that two things were identical, when in fact they were different.

Something very similar happened with concert-hall acoustics. There was the famous debacle of the Philharmonic Hall, which preceded Avery Fisher Hall at Lincoln Center in New York City. In that original design a certain measurement of the time of resonance was matched flawlessly to the value that was found in the best older halls. But everyone's ears said that the acoustics of Philharmonic Hall were in fact dreadful. A measurement that was supposed to provide a good summary of a concert hall's acoustic properties had turned out to focus on something that differs from what the ears care about. Our senses and brains have a feeling for shape that's extraordinarily honed by evolution and experience.

Omni: As an outsider coming into so many specialized fields, was it hard to find a sympathetic response?

Mandelbrot: Yes. It's astonishing how much science is reduced to a sport. The value of a scientist's work is determined by the amount of competition he's encountering; you're judged by the amount of competition in your "event." You're not a real athlete until you've run the hundred-yard dash. I chose problems in which competition was nonexistent—not because I'm afraid of competition. I picked mountains and coastlines because there were no specialists in the study of these problems. I had the field to myself. Having no competition was an asset. Now everybody is watching over my shoulder, and I get referees who go into great detail because they're competent to do so.

Omni: Do you approve of the referee system for reviewing technical papers?

Mandelbrot: For most established fields the referee system is perfectly good, though I think no one loves to referee or to be ref-

ereed. It's better than the system in which one all-powerful editor or foundation executive decides on a whim whether to accept or reject a paper. But for years I had an impossible time with referees and with every other established form of peer review. To state the problem bluntly, since I was all by myself, I had no peers. I had the personality to be able to work alone, but I did not enjoy having to argue with referees who did not even pretend to be my peers. They had to be broad-minded to agree to read my papers in the first place, but they did not really care, and their decisions were not to be trusted.

Omni: I have heard you use the term *technical mathematician*. What do you mean?

Mandelbrot: A professional mathematician can be compared to a professional chess player. To be a real chess player, you must have studied quite deeply all the great games of the last century or more. If you haven't, you aren't anywhere. You aren't in the big leagues if you make mistakes that somebody made a hundred years ago and that everybody else knows how to avoid. As a child I was a chess champion. I retired at age eleven because I went from a place where everybody played chess and there was a championship for kids to a place where nobody played chess. In retrospective I was lucky, because I played intuitive chess. I had a feeling for spatial relationships of pieces and so on. I had stamina. I was a fighter. But I hadn't read all those games.

To do well in mathematics, in addition to having talent and skills, you must be able to recall instantly the way various technical problems have been solved. Some people who do this supremely well become known as great technicians. I am not at all a technician. It is not a skill one can maintain on a part-time basis. But I know many admirable problem solvers, and I often seek them out to offer them my half-baked ideas on difficult problems.

Omni: Would you describe yourself, then, as an applied mathematician?

Mandelbrot: No. I have never indulged in the activity that ordinarily goes under this name. The caricature of the applied mathematician is that of a consultant who takes mathematical techniques he has not developed and applies them on request to problems he has not posed.

So what should I be called? Some people do call me an experimental philosopher, because there is no question I am a philosopher at heart. But in one sense I'm a "mathematician-without-hyphen," not a pure-mathematician or an applied-mathematician or a mathematical physicist. And I'm one of the few people plying this trade today. For *Who's Whos*, I put down MATHEMATICIAN AND SCIENTIST or even MATHEMATICIAN, SCIENTIST, SCHOLAR, AND ARTIST, which upsets editors, who prefer one word. I was once appointed a visiting professor of physiology at a medical school (unpaid, I hasten to add, and I saw no patients). After my host and I had worked together, he wanted to make a gesture of acknowledgement. He said, "It is obvious that your life ambition is to retire as a professor of divinity after having been a professor of aesthetics, so to help you on your way I'll make you a professor of physiology."

Omni: Where does aesthetics come in?

Mandelbrot: Quite unexpectedly. Once fractal shapes were drawn correctly, they were viewed by many as being beautiful. Some of them are old shapes, even a hundred years old. Yet they were never before looked at carefully because they had been introduced as monstrous, counterintuitive, bizarre, and impossible. Faced with these shapes, mathematicians and scientists covered their eyes. They were prepared to visit the freak show on rare occasion but not to live on a daily basis with monsters. The old pictures made of them were very few, astonishingly inaccurate, poorly executed, and haphazardly chosen. When computer graphics made it possible for me to draw them correctly, a striking harmony

"It's astonishing how much science is reduced to a sport. The value of a scientist's work is judged by the amount of competition he's encountering, the number of people in his event"

was suddenly revealed.

Omni: Harmony in what sense?

Mandelbrot: Many years before I formulated fractal geometry, I had heard the famous mathematician and physicist Hermann Weyl lecture at Princeton. These lectures eventually gave rise to his marvelous book *Symmetry*. Weyl emphasized that for the ancient pre-Classical Greeks the idea of symmetry was far richer than today's narrow notion of right and left, or mirror, images. For them, symmetry expressed a kind of harmony between the parts and the whole.

Now, many of our monstrous maids, whose married name is fractals, are self-similar, that is, they are structures in which each part is the same as the whole, only smaller. Hence, they are symmetrical to the most extreme degree. This may be why it happens so often that fractal pictures are perceived as being extremely strange yet wholly familiar. They are much stranger than deliberate special effects in science fiction, because science fiction is in most cases remarkably humanoid.

Having done time with self-similar fractals, I moved on to fractal dragons, in which the parts obtain from the whole by a certain mathematical deformation. These dragons are generally perceived as even more beautiful—very strange, yet somehow familiar.

Omni: Can fractal art be minimalist?

Mandelbrot: Yes, to an unusual degree. Try to describe even the most minimal art so precisely that one could reproduce it exactly. To do so would require an extremely long description in words. But the equation that generates a fractal dragon is one line long, and if you give it to someone with the right intellectual and computing equipment, he will be able to reproduce it exactly. So this art is the most minimal of all. It is astonishing that something that is logically so minimal can contain such a wealth of characteristics. The interesting thing isn't just generating flamboyant, baroque behavior from complicated formulas but seeing how cheaply we can get rich shapes from very simple formulas.

Compared with other work shown in exhibits of computer art, I find that our fractal mountains are not only the best art but also the most novel, because we deliberately put in the least possible amount of willful intervention. We do not improve upon our simple formulas by imposing our mediocre skills as landscape painters, and the art achieved in this fashion is much purer. On the other hand, I'm sure that once artists become familiar with the new fractal medium, some are going to do great things with it. Pure geometry can look beautiful by accepted standards of beauty.

Omni: Most people would think of scientific art as stark and austere rather than flamboyant and baroque.

Mandelbrot: When people say that modern buildings are soulless and not on a human scale, what do they mean? I never heard anyone say that the Paris Opera is not on a human scale, yet it's an enormous building. Why doesn't it elicit that feeling? Because the architect Charles Garnier incorporated features of every scale. Wherever you stand—at the end of the Avenue de l'Opéra or right smack in front of the building—there is something you can see that is at your scale. It has symmetry in this old Greek sense: harmony between the parts and the whole. But a Mies van der Rohe building is designed to be aggressively nonsymmetrical, even if it is a one-room box. I started making these remarks around 1970; they were viewed as bold, but today they have become tame. Today we are surrounded by Bauhaus renegades, who leave no long line unbroken and no blank, large surface anywhere.

In old masters' paintings or in beaux arts architecture in its heyday, I see a deliberate and successful imitation of nature's elements of scale. Fractal designs recall the beaux arts style, even baroque. But they avoid the rococo manner of filling every available space with decoration, a kind of aesthetic overkill. The surface of an old master's landscape is never filled with detail. It is filled mostly by the sky. The sur-

face of an old master's portrait is mostly given to drapes or perhaps a robe This balance between what is filled in and what is left blank provokes a feeling of plenitude Fractal geometry has shown that a similar feeling can be evoked by shapes drawn according to a simple formula This is a genuine aesthetic discovery It is the same kind of balance the Scandinavian furniture designers found when they started building simple forms with richly grained woods The rosewood grain is part of the design The same furniture made with a bland wood looks dreary It doesn't have the detail to balance it

Omni Can you make a fractal equivalent of the "Auditory Penrose Staircase" the illusion of a steadily descending tone, by zooming in on a fractal as it branches?

Mandelbrot To me M C Escher's drawing of the "Penrose Staircase" is a sort of pathology of the eye I try to live where the eye is sensitive to nuance, and to me, that image is monotonous, the same thing going around and around endlessly But zooming in endlessly on a fractal landscape is something else You think you're going to crash but you don't You get more detail

Omni Why is it that fractal mathematics can be applied to living forms to create artificial trees and animals?

Mandelbrot It cannot be accidental that so many fractal shapes suggest snails, jellyfish or other forms of life It raises a basic question of biology How much genetic coding is needed to obtain the diversity and richness of shape we observe in living beings? If you compare all the tiny and irrelevant differences in two species of lobster you ask yourself Why would nature have evolved such an exuberance of form without obvious use? I mentioned that fractal shapes of great complexity can be obtained merely by repeating a simple geometric transformation, and small changes in the parameters of that transformation provoke global changes This suggests that a small amount of genetic information can give rise to complex shapes and that small genetic changes can lead to a substantial change in shape

Omni Why do you claim that parts of the human body are fractal?

Mandelbrot Consider the development of the mammalian lung which is an extremely complicated structure of tubes air sacs and blood vessels It would take an enormous amount of information to specify it in detail But the instructions are very short During the development of the fetus a simple budding process is repeated over and over twenty three times The packing of soft tissue within a confined volume creates the final structure If the diameters of the bronchi were decreasing any faster as one moves away from the nose the lung would be loosely packed—a bad design If the diameters of the bronchi were decreasing more slowly, the growing buds would be too closely packed and would interfere with one another

Omni Did you suspect from the beginning that all these applications of fractals would form a unified whole?

Mandelbrot It was a very gradual development, with many intermediate stages My early unified wholes did not cover much territory but they were followed by increasingly ambitious extensions From the very beginning, I had been on the lookout for structures of broad general validity Nevertheless the actual search for these structures involved a gamble—a gamble on which I staked everything Friends kept warning me against involving myself in so many disparate fields but I felt that getting into more different fields would make my life not harder but easier I was fortunate to win the support of Ralph Gomory now IBM vice-president for research who has been my boss for twenty five years

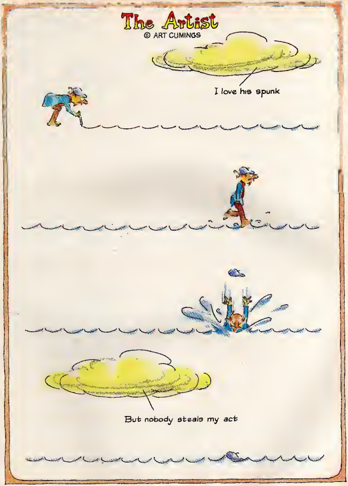
The logic of what I was doing did not really become apparent until ten years ago I had been invited to summarize my work in a lecture at the College de France As I prepared the lecture I began to see a very effective way to order my material After I spoke, there was an hour long question-and-answer session in which people in a dozen different disciplines asked questions I managed them all This led to an unpublished article which grew into my 1975 book *Les Objets Fractals Forme, Hasard et Dimension* It was translated into English in much expanded form and in 1982 it was heavily revised and expanded again into *The Fractal Geometry of Nature* which was published by W H Freeman

When the 1975 book was nearly ready, I had to give it a title Clearly it could not be called *Applications of the So-called Mathematical Monsters to Practical Phenomena!* That is when I coined the word *fractal* There is a Latin saying To have a name is to be By giving a name to this synthesis, I felt it had taken shape Now the word is in several dictionaries and people flatter me by misspelling it indicating that it has become a part of their thinking not a new word they must be careful about I've gone from being a fellow who was wasting his time on something nobody could see the point of to a fellow who is belaboring the obvious!

My Ph D thesis was completed in 1952 so the little more than thirty years of my career as a scientist divide neatly into spans of ten years The first decade was one of groping The next ten years were spent in formulating a broad enterprise with no distinction between the social and physical sciences And the last ten years have been a period of consolidation

Omni Do you no longer consider yourself to be on the eccentric fringe?

Mandelbrot Yes the element of solitude is gone The element of noncompetition is gone The element of amazement is gone although the pleasure remains What will the next ten years bring? I don't know Ive only scratched the surface of everything Ultimately it's a matter of how much unity can be created by this one idea And the ultimate test is the test of time ∞


The Artist
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I love his spunk
But nobody steals my act

CONTINUED FROM PAGE 22

earlier the prince was in mourning. But he felt his presence at the launching was in keeping with the Mountbatten spirit.

Divided between land, air, and ship—and including film crew, radio team, and scientific researchers—the team grew to 29 members. One group stayed aboard the *Benjamin Bowring*, another airlifted food and supplies to the only two who never left the ground: Sir Ranulph and Burton. Throughout the trip, Lady Fiennes was in charge of communications, monitoring everyone's movement via radio and making sure equipment was available when needed. She also kept in touch with England and took care of administration, fund-raising, and maintenance of all radios, masts, and antennas.

Sallying forth by Land Rover across the Sahara from Algiers to the Ivory Coast, the Transglobe travelers fulfilled their obligation to the natural-history section of the British Museum by collecting lizard, bat, and snail specimens. They then drove to Cape Town, South Africa, and set sail for Sanae Buchte, in Antarctica. From there they traveled by snowmobile to Borga, their base for an eight-month winter stopover, a winter whose darkness had defied many an explorer before them.

Sir Ranulph's Antarctic route was inspired by one of the truly epic events of British exploration: the successful but tragic trek of British naval officer Robert Scott. After hauling heavy sledges by hand over mile-high polar plateaus, Scott's expedition reached the South Pole on January 18, 1912—just 35 days after Roald Amundsen, the Norwegian explorer renowned for his navigation of the Northwest Passage. But Scott's five-man team was beset by blizzards, frostbite, illness, and lack of food. Two men died. Scott was only 11 miles from his depot when he was assailed by yet another blizzard. He and his last two crew members eventually collapsed and froze to death.

The Fienneses, Burton, and Shepard were the only members of the team to weather the winter. "We were like three brothers and a sister," remarked Ginnie. For eight months, cardboard huts were their castles. Burton was on kitchen patrol and serviced generators. Shepard took meteorological readings as well as sophisticated measurements of the earth's magnetic field activity. Ran kept the 50 yards of tunnels between the main hut and the research and radio stations clear and worked on a "trashy mystery novel." Ginnie continued putting in long hours at the radio shack, resoldering connections, unraveling wires tangled by high winds, and digging out blizzard-buried antennas.

Despite predictions of disaster from Antarctic experts, the three men set off for the South Pole on snowmobiles. Ginnie stayed behind to monitor the radio and coordinate supply drops to the party via a Twin Otter plane. When the men arrived at the South Pole on a sunny day in December 1980, they were seven weeks ahead of schedule. To celebrate they played a quick game of cricket.

After rejoining their ship on the Pacific side of Antarctica, the team continued its route from McMurdo Sound to Auckland, New Zealand, then on to Sydney, Australia, and up to Los Angeles and Vancouver, in British Columbia. At the mouth of the Yukon River they were lowered into the stormy water in inflatable, motorized rubber rafts. The team wound its way up the Yukon and onto the MacKenzie River, navigating the entire treacherous Northwest Passage in a mere six weeks.

But success was not yet theirs. The supplies they needed to reach the North Pole were destroyed by a fire in the base camp at Alert. Ran's snowmobile, a Ski-Doo full of supplies, broke through thin ice and sank some 17,000 feet to the bottom of the Arctic Ocean. Sir Ranulph and Burton (Shepard having had to leave the party for domestic reasons after reaching the South Pole) hauled the remaining sledges by hand. Because of the mild winter when they finally did reach the North Pole, they encountered mile after mile of unstable ice and were often unable to travel by snowmobile. Ran's advisers wanted to airlift the party out of the precarious Arctic Ocean, but the expedition members refused, choosing to ride an ice floe, "like a crouton in chilled consomme," until the spring thaw enabled them to drift southward toward the North Atlantic and once again hook up with the *Benjamin Bowring*.

For 90 days they rode the ice, putting up with unexpected visits from wandering polar bears, until finally, after heaving, hauling, and paddling (they had abandoned their snowmobiles for aluminum canoes) through the "swampy ice porridge," the two men heard the familiar strains of the Eton boating song drifting across the ice from their mother ship. They had set another record by crossing the Arctic Ocean in a single season.

Although the Transglobe Expedition was intended to boost the national spirit of the British people, the adventure received its share of criticism. How, some Britishers wondered, in the midst of severe economic recession and unemployment could good money be raised for such a showy, indulgent exhibition? Nevertheless, on August 29, 1982, the triumphant *Benjamin Bowring* and crew rolled up the Thames to Greenwich, where they were greeted amid fanfare by Prince Charles, who praised them for their "courage, endurance, willpower, and sheer bloody-mindedness."

A happy aftermath of the Transglobe Expedition was 13 marriages, six births to crew members, and this astonishing declaration from Lady Fiennes: "I would dearly *love* to do the expedition all over again." A surprised Sir Ranulph raised his eyebrows a bit when he heard that. For some reason he didn't seem to like the idea. **OO**

DESERTED

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broke off a thumbnail-size piece. It smelled like damp earth.

He put the mushroom in his mouth, chewed it carefully, and swallowed.

With his back against the smooth bole of a ramon tree, he shut his eyes and let the night sounds of the forest close in on him. In the distance, over the chatter of insects and the bubbling call of tree frogs, he could hear monkeys crashing through the high branches.

Fifteen minutes later the drug took him with a kick that nearly lifted him off the ground. His heart raced, and he felt the dizzy, roller-coaster rush of the alkaloids attacking his metabolism.

Jesus Christ, he thought, *all this from one tiny piece?*

The darkness around him came alive with incandescent-purple highlights. The mushrooms in the grove snapped into high relief, as if lightning had just struck behind them. The grove seemed suddenly to extend endlessly in all directions.

Ryker's eyelids dropped, and he fell into starless night. Ahead of him a double helix made of red, green, and yellow neon spiraled toward infinity, pulling him with it.

He shook his head, and images began shooting past him like speeding cars, the roar of their passage brutalizing his stomach and chest muscles.

Each image was a tiny window, and beyond each window lay a synthetic nightmare of compressed experience. He was fighting to breathe, and he knew that if the windows opened for more than an instant, the intensity of the experience would vaporize his personality.

He forced his eyes open. The skin of his face was burned raw by salty sweat. He blinked, focused, and saw three faces staring at him from the jungle's edge.

The man in the center was naked, and the men on either side wore the long, white robes of Mayan villagers. Their bodies glowed softly in the moonlight.

Slowly Ryker extended his empty hands and greeted them in Mayan. "*Utz in puksiqual*," my heart is good.

The glowing figures did not answer, and when Ryker blinked again they were gone.

In another five minutes the effects of the drug had passed, leaving Ryker numb, exhausted, and a little afraid. He crept back to his tent and fell heavily into bed.

He woke up with the sensation of floating, then felt himself bounce into the mattress. Struggling to wake up, he gripped the steel edges of the cot.

Quake, he thought. *A light one, nothing like the one he'd been through in Mexico City. But had it really happened, or was it just another hallucination?*

He tried to pull himself out of bed, but his strength failed him, and he fell back into a long and dreamless sleep.

By the time he got up in the morning, still shaky from the mushroom toxins, the others were at work. He was drinking a cup of lukewarm coffee when Lindsey sat down next to him.

"I was looking for you last night," she said. "I wanted to talk to you."

"What about?"

She shrugged. "I just wanted to talk. It's so awkward, feeling like I don't understand you anymore. I thought we could start to get to know each other again. But I couldn't find you."

"I had to . . . go out for a while."

"You went back to the mushrooms, didn't you?" she accused.

He looked down at his coffee.

"You tried it, didn't you?" she said. "Even after what I told you. Even at the risk of destroying your mind."

"I had to," he said softly.

She got to her feet. "I can't get through to you no matter what I do. I'm just wasting my time." She walked away angrily.

"The drug took him with a kick that nearly lifted him off the ground. His heart raced, and he felt the dizzy, roller-coaster rush of the alkaloids attacking his metabolism."

They'd set up the experiment in a clearing near the mushroom grove. Through a gap in the trees Ryker could see the towering mountains to the south of them, just over the border into Guatemala. The highest peaks were still wrapped in swirls of mist that would burn off by noon.

His eyes kept coming back to the man in the center of the clearing. Lindsey was fitting small Teflon dots on the man's neck, chest, inner thigh, and temples. These would send continuous readings to a processor a few meters away.

Four cameras mounted on the surrounding trees were focused on him, and the entire area was wired for sound.

The man was a pure-blooded *indio* from a village near Ococingo. His name was Juan Garcia, and he spoke fluent Spanish, but everything else about him was Mayan, from his long robe to his thick, black hair and hatchet nose.

He was the man Ryker had seen standing naked in the grove the night before.

Garcia had shown up that morning with the two other men that Ryker had seen, announcing that finally, after two weeks of delay, the time was right for him to take the drug. They'd made no sign of recognizing Ryker, and the two other men had quickly disappeared back into the forest.

Garcia had a cloth bag full of the mushrooms. According to everything Ryker had been able to find out, Garcia would go into a light trance within a few minutes of eating the plants and wake up about two or three hours later with vivid memories of a prior existence. Ryker would then be on hand to translate any difficult terms or explain unusual customs.

Ryker was still weak and disoriented from his own experience and suspected that Garcia's trip would be more grueling than any of the others imagined.

As Garcia began to eat the mushrooms, Ryker moved over to Oishi's workstation. "Busy?" he asked.

"Not too," Oishi said. "What's up?"

"I need a program. Something that will be able to convert dates to and from the Mayan Long Count. Do you know what I'm talking about?"

"Only vaguely. But if you can give me the numbers, I'm sure that we can put something together."

Ryker quickly showed him the system. Each date had five places, the number on the far right representing days, preceded by twenty-day *uninals*, working all the way up to one-hundred-forty-four-thousand-day *baktuns*.

"You're starting from August—Jesus, what is it? August the twelfth, that's right, 3113 B.C., which is written 13.0.0.0.0. Okay?" Ryker wrote it out for him on a slate. "That's as high as it goes—thirteen *baktuns* is the end of a cycle. So the next day would be 0.0.0.0.1."

"No problem," Oishi said.

Ryker moved back to where he had a better view of Garcia. He might not need the dates, but it was better to be safe. He was rusty with the numbers, hadn't even thought about them in years.

Something was bothering him about the dates, something he couldn't quite remember, but the sound of Lindsey's voice made him lose the connection.

"How many of those is he supposed to be eating?" she asked Camarena.

"Didn't he say two or three?"

"That's his fourth right there."

Garcia was eating quietly, the mushroom caps making no noise at all, the stalks crunching just a little like limp celery. He pulled a fifth mushroom out of the sack and began to eat it.

"Shouldn't we stop him now?" Lindsey whispered nervously.

"He knows what he's doing," Camarena said. "Doesn't he?"

"He's being polite," Ryker said, interrupting. "He wants to be sure to give you a good show."

Lindsey touched the Indian's shoulder and waved her hand at the bag. "*Ya basta*," she said. "*No mas*, okay?"

"Okay," Garcia said.

Ryker was both envious and amazed. A tiny piece of one of those plants had dev

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February 1984

astated him yet he had watched Garcia eat five of them.

And yet if the drug really worked if one of those alkaloid windows could open on the city in its prime Ryker would have given anything to see it. The jungle pushed back the temples pristine and shining white the frescoes painted in rich colors the palaces crowded with feathered priests and sumptuous women.

Close to ten thousand people had once lived in the area surrounding the temple complex their clusters of stick houses on pedestals covering the surrounding hillsides for miles. In the ball courts the players flaunted their costumes and agility for the nobles while massed ranks of soldiers drilled nearby. The market was packed with traders and craftsmen and artists the air rich with the smells of cooking and copal incense.

And somewhere in the city in the mind of a priest or an astronomer or a sculptor who carved the stelae for the temples there was the key to Ryker's obsession. It might be in the calendar with its three separate cycles, a time scheme so convoluted that no Western mind could grasp it completely. It might be in the religion in the multitude of gods each an aspect of at least one other—a theism so complex that scholars identified the gods with letters of the alphabet rather than proper names.

Or it might have been something even more abstract and visionary. Ryker's mind filled with images of quetzal feathers serpents and stucco skeletons. He didn't realize he'd dozed off until a sudden movement in the clearing brought him around.

He checked his watch. About thirty minutes had gone by more than enough time for the drug to take effect. Garcia was staring around him with frightened eyes whispering in Mayan.

"*Baax a kaab? Baax?*" What do you want? What's happening?

The first thing Ryker noticed was the accent. It was close to that of the Lacondones but even crisper and more precise. *Ancient Mayan*. Ryker thought.

Then he saw Garcia's face.

The man had been transformed. His features were the same as a minute before but a different personality was looking out through them. A sudden new intelligence lit the eyes and the mouth was working with fear and disbelief.

"I thought he was supposed to be in a trance," Lindsey stage whispered.

Ryker stood up slowly licked his lips finally managed to speak. "I don't think," he said quietly "that he's Garcia anymore."

"Who are you?" the man asked again in his strange delicate Mayan.

"We are . . . travelers," Ryker said trying to match the accent. "We brought you here to ask you some questions."

"*A qu-ob-etsh?*" Are you gods?

"*Ma*. We are men like yourself."

Ryker began to sweat. This was nothing like what he'd expected. No one had ever dreamed of having a live informant from the Classic period. Ryker had no idea how much time he had could only hope that he asked the right questions that he would get the answers he needed.

"What is your name?" he asked.

"Chilam Sotz," the man replied nervously. "I am *Ah Qin*."

Ryker couldn't believe his luck. *Ah Qin* meant chief priest of the city. "The year," Ryker said. "What year is it?"

The man recited the count slowly, sketching line and dot numerals in the dirt. Ryker copied them into modern numbers, 10 2 5 17 17, and handed them to Oishi. "Run that for me will you?"

Ryker knew it would be late. The last stelae dated in the Long Count came from 10 3 0 0 0 just before the collapse of the culture. *My God*, Ryker thought, *this Chilam Sotz was there. He was an eyewitness to the devastation that wiped out ninety percent of the Mayan population in the course of a few generations.*

Oishi handed him a date: July 16, 874.

The man had been transformed. His features were the same, but a sudden new intelligence lit the eyes, and the mouth was working with fear and disbelief

"I don't feel well," Chilam Sotz said. "What is happening to me?"

Ryker decided to risk a little of the truth. "You have eaten a mushroom. It has brought you to us."

"The mushroom," the priest said. "Of course. The mushroom."

Lindsey was feverish with impatience. "What's going on?" she blurted in English. "Dammit, what's he saying?"

Ryker waved her quiet and said to the Indian, "Your people are dying. Every year there are fewer children. Why? What is happening to you?"

"It is time," Chilam Sotz said. He used the word *qin-il*, the suffix indicating time in the abstract.

"I don't understand," Ryker said.

"We act as we must in this part of the cycle. For each part of the cycle there are things that must be done."

Ryker tasted blood. In his excitement he had chewed through his lower lip. He touched the cut abstractedly with one forefinger and said, "What things? What must be done?"

"In the first *baktun* man is created. For three *baktuns* he is a savage, for three *baktuns* he learns language and becomes civilized, for three *baktuns* he builds and reaches greatness, for three *baktuns* he prepares for the end."

Each *baktun* was about four hundred years. Ryker had known that the Maya thought in periods much greater than their own lifetimes but to hear the priest talking in terms of millennia was staggering.

"The end?" Ryker asked. He smoothed out the ground between them and wrote the lines and dots for 13 0 0 0 0.

"*Bei*," the priest agreed. His single sharp nod was more a gesture with his chin than with his whole head.

"Then you really believe that the world will be destroyed at the end of the cycle."

"Believe? It is not a matter of belief. It is a matter of time." Again that word *qin-il*.

Slowly Ryker began to understand. Not "time" at least not in any sense Ryker knew but rather "Time," a force, a power that shaped and controlled. It explained so much—the different aspects of gods at different times of the year, the sudden flurry of building, the equally sudden demise of the great cities of the forest.

Was that what was happening now to Ryker's own civilization? Was it Time for them as well?

"But the end," Ryker insisted. "What happens at the end? A literal disaster? A real flood or fiery rain?"

But Chilam Sotz was not answering. He had discovered the black dot on his neck and was attempting to peel it off. Ryker touched his arm gently and said, "No, please."

The priest stood up. Ryker watched his gaze move from the machines around him to the distant hills to the sun to the shattered buildings beyond the clearing.

"Something is wrong here," he said finally. "You are not gods. You are not *mam-ob* either."

Mam-ob. The Old Ones. According to what Ryker had been taught, the Old Ones were the gods of the mountains and valleys. But if Chilam Sotz said they were not gods then—

Ryker's head spun. The other meaning of *mam-ob* was "grandfathers." Ancestors. Thanks to the mushroom, Chilam Sotz's people would have known their ancestors intimately. *Christ*, Ryker thought, *how could they have anything but a totally deterministic philosophy? The entire memory of their race was available to them anytime they wanted it, just as their own lives would be available to their descendants.*

Chilam Sotz' was starting to panic. "I know this valley. But what has happened to the city? Why have you taken me out of the cycle?"

"Just what the hell is going on here?" Lindsey wanted to know standing up next to the Indian. "I demand to know what's happening!"

"He's freaking," Ryker said. "I think he just figured out where he is."

"*Where* he is?" Lindsey seemed close to hysteria. "Ryker, for God's sake. Don't you

have any idea of what I went through to bring you here? Don't screw this up!

"I can talk to him," Ryker said. "It's okay."

"It better be. What date did Oishi give you? Is that what he's remembering?"

"Not just remembering. He's living it."

"Oh, Christ," Lindsey said.

"The date," Chilam Sotz' said. "What is the date?"

Ryker turned to Oishi. "Give me today's date, will you?"

Oishi nodded and a moment later handed him a slate. At the top it read DECEMBER 23, 2011, and underneath were the numbers 12 19 19 17 19. While Chilam Sotz' shifted nervously from side to side, Ryker transcribed the numerals into Mayan.

For a second the Indian was absorbed by the novelty of the slate, turning it over in his hands and touching the surface lightly. Then he saw the writing on it and his eyes bulged.

"Oh my God," Ryker whispered the meaning of what he'd written finally coming to him. "Oh my God—"

Chilam Sotz' looked into Ryker's eyes in stark terror. "*Ah Puch*," he said and ran into the jungle.

Camarena and Oishi sprinted after him, but in seconds he had disappeared. Lindsey dropped to her knees and slammed one fist into the dirt. "What the hell happened?" she asked, spitting out one word at a time. "What did he say to you?"

"*Ah Puch*."

"*Ah Puch*? That's God A as the death god."

"That's right. His special job is to watch over the end of epochs."

"I don't get it. What are you saying?"

Ryker handed her the slate. "Add one day to those figures. Know what you get? 13 0 0 0 0. The world ends tomorrow."

"No," Camarena said. "You're out of your mind. I am not even going to consider abandoning this expedition because of some Mayan superstition."

The inside of Camarena's tent seemed hideously cold to Ryker. He folded his arms over his chest and looked over to Lindsey for support, but she only stared down at the tabletop.

"Where have you been for the past twenty years?" he asked Camarena forc

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HYCA0

ing himself to keep his voice down. "You're using Kirlian cameras on this dig. Yevtushenko proved the existence of thought waves fifteen years ago. Then there's Rosen's work with the Lemurian cultures and Gnostic almanacs. I'm not talking about superstition. I'm talking about science. Science changes, expands to take in new ideas. That's the point. Monadic physics would have been a joke thirty years ago."

"Is this a history lesson?" Camarena asked, getting up out of her chair at last. "Because if it is, there is some history I could remind you of. Such as the fact that you never finished your Ph.D. You've spent the last five years stumbling around in a haze of drugs, waiting tables or playing Indian, and you want me to take your word that the sky is falling?"

"Lindsey?" Ryker said. "Do you think I'm crazy, too?"

"I don't know." Her voice was so low Ryker could barely make it out. "I could never manage to believe in things the way you do. You know? You've got this weird obsession with *clarity*. You think that if you take drugs or starve yourself or go live with some tribe in the jungle, then everything will be come clear."

Finally she looked at him, and her eyes were puffy and shot with red. "But it never does. And it's never going to. Because life is murky. All that happens is that you get more and more detached and obsessive until people just can't care about you anymore. Even the ones who want to."

"You can't blame me for this," Ryker said. "Do you think this is my own little fantasy? Why did Garcia hold off until today? Why did he take so many mushrooms that another personality could take him over? Why did that personality just happen to be a high priest, who could give us the warning that he did? Do you think I invented that date? Do you think this is all some bizarre coincidence? Because if you believe that you're going to stay here in this valley and you're going to die."

Camarena slumped back in her chair. "There are two copters at the landing strip. One of them can take you back to Villa Hermosa and then you're on your own."

"You won't come."

She shook her head. "You're convinced there's some kind of destiny working itself out here. Then I guess my destiny is to stay. I've worked my whole life for this, for my own expedition, for a site as rich as this. No. I'm staying."

"Lindsey?"

"What is it you want? An act of faith?"

"No." Ryker said. His hands and feet felt numb from the cold. "I just want you to come with me."

"All right," she said, looking down again. "All right."

He sat by the ashes of the campfire waiting for Lindsey to pack. She had found two of the grad students who'd wanted to come with them. Ryker suspected that they were just tired of the heat and the hard work and the insects, but he didn't question their motives.

He was beyond questioning anything. He felt himself caught up in a torrent of events that left no room for hesitation. His eyes moved to the sun, dropping beneath the tops of the trees on the western end of the clearing.

So much had happened since the last sunset he'd watched.

Suddenly he was on his feet, running for Lindsey's tent. He tore open the door, surprising her with a handful of clothes poised above her travel bag.

"Hurry!" he shouted. "Grab what you've got! We have to get out of here!"

"What—"

"Sunset!" Ryker shouted, seeing his own fear beginning to infect her. "The new day starts at sunset!"

They headed for the landing strip at a shambling run, Lindsey leading the others, Ryker bringing up the rear.

He was lying on his face, tasting blood and feeling the shock of impact in his wrists. Thunder roared in the mountains. He pushed himself up and stumbled on.

As the sun dropped behind the mountains Ryker felt the crystalline sense of destiny that had brought him that far suddenly disappear. He slowed to a walk, thinking, *I don't even know what this disaster is supposed to be. What if I'm wrong? What if—*

He was lying on his face, tasting blood and feeling the shock of impact in his wrists. Thunder roared in the mountains overhead. *Movement*, he thought dazedly. *The fifth sun.*

Earthquakes.

"Run!" Ryker shouted. "Run for it!"

He pushed himself up from the dancing ground and stumbled on, sometimes slipping to one knee, sometimes losing his balance completely. Lindsey and the others were just ahead of him, not doing much better than he was.

He was just getting to his feet after a bad shock when someone stepped in front of him. "*Que pasa?*" Juan Garcia asked in a dazed whisper. "What's happening?"

Ryker searched for a trace of Chilam Sotz' personality in the Indian's face, but it was gone. He gripped the man by the shoulders. "Do you remember?" he asked in Mayan. "Do you remember any of it?"

"Yes," he said abstractedly, now speaking Mayan as well. "I remember."

Ryker took his arm, and together they staggered into the clearing. Lindsey had one of the pilots already warming up a copter for them. The other pilot was pacing back and forth beside his machine, obviously frightened and confused.

"Wait for the others as long as you can," Ryker shouted to him in Spanish. "But save yourself, okay?"

"*Si, hombre.*"

Ryker pushed Garcia into the copter and as soon as he got the door closed behind them the machine leaped into the air. As he took a seat next to Lindsey the ground below them rose like an ocean swell and then cracked down the middle with a sound like cannon fire. Hot gases spurted from the wound.

"Take her up and hover," Ryker shouted to the pilot.

The ground shrank to the size of a model railroad layout. Off to his right Ryker could see the top of the great pyramid just poking through the surrounding jungle. As he watched, it shook itself to pieces and disappeared. The air was filling with dust and steam and the agonized sound of rock grinding under pressure.

Tiny human figures appeared in the clearing, on the wrong side of the fault from the remaining copter. They waved and seemed to be shouting as the machine tried to take off for them. It bumped along the ground like a broken toy, then fell slowly onto its side. The rotor caught in the earth and gently tossed the copter into a tree, where it burst into flame.

"Can we go back for them?" Ryker asked the pilot.

"No chance," he said.

"Then get us out of here."

"Where to?"

"I don't know yet."

The pilot switched on a radio. "... San Andreas Fault has finally lived up to the predic— He spun the dial. "... *muertos en el ultimo*— ... still more earthquakes all across Europe and Africa—

"How much air time have we got?"

"Twelve, fourteen hours."

It should be enough, Ryker thought. *Enough to get someplace far enough inland to be clear of the tidal waves. Enough to find other survivors, to prepare for the new sun.* He collapsed into the cushioned seat and squeezed his eyes shut.

At least they'd saved Garcia. And his memories of Chilam Sotz, whatever they were. That seemed important somehow. It would be important because this time there were people surviving, not just the monkeys and the parrots and the fish from the ancient myths.

Ryker felt the touch of Lindsey's fingers on the back of his hand, tentative, questioning. He took her hand in his and held on to it tightly.

This time, he told himself, *things were going to be different.* □□

GAMES

ANSWERS TO GAMES (PAGE 121)

GENERAL INFORMATION

1 (d) Nothing. David Koskoff, in *The Diamond World*, says that kimberlite has been called "the world's most useless substance." It expands, contracts and disintegrates so readily that it cannot be used as a substitute for either sand or gravel in the construction industries, and it is useless even for landfill.

The mountains of discarded kimberlite have become an eyesore throughout diamond country. Whenever methods of extracting diamonds get more sophisticated, old piles of kimberlite are picked through again for smaller diamonds, and the kimberlite is again discarded.

2 (a) True. The optimum diamond cut was not worked out until early in this century.

3 (c) and (d). The world's only public diamond mine is in Murfreesboro, Arkansas. For $2 a day you can search all you want and keep whatever you find. The locals swear that some big D-flawless stones have been found here.

4 (f) or higher—about $17,000 in fact. There is no economy size in diamonds. Larger stones cost more not only because of their extra size; they cost more *per carat* because they are rare.

If a one-carat stone sells for 100 units per carat, a three carat stone might cost, say, 235 units per carat.

A diamond that weighs slightly less than a carat may be a better buy than one that's just one or two points over a carat. One carat is a critical psychological cutoff, and people like to own stones this large or larger. In order to keep its weight up, a stone just barely above a carat may not have been given its optimal cut.

A stone that is slightly below the psychological cutoff may have been given its best possible cut without concern for the final weight.

5 There is no comparison. The similarity of the two terms is coincidental. Karat is a measure of gold purity: 24 karat is pure gold; 18 karat is 75 percent pure; 14 karat is 58.5 percent pure; and 10 karat is 42 percent pure. Carat is a measure of weight for precious stones.

6 (f) 7. Though the terms sound similar, there are several gradations between. For the record:

1 flawless
2 internally flawless
3 very very slightly imperfect 1 (VVS1)
4 very very slightly imperfect 2 (VVS2)
5 very slightly imperfect 1 (VS1)
6 very slightly imperfect 2 (VS2)
7 slightly imperfect 1 (SI1)
8 slightly imperfect 2 (SI2)
9 slightly imperfect 3 (SI3), and so on.

All of this reminds us of the 12 grades of California olives, with small, medium, and large being the three smallest.

7 (g) General Electric did it in 1955. Today *most* industrial-grade diamonds are artificially created using nature's own recipe: carbon and pressure. DeBeers started making its own diamonds in 1959.

8 (h) An ounce of top-quality (D-flawless) diamonds could be expected to bring more than $5 million. But an ounce of highest-quality diamonds would easily fit inside a standard cigarette pack, whereas $5 million worth of gold would fill a small truck.

GEOMETRY

1 There are 33 facets above and 25 below.

2 There are eight four-sided facets. The octahedral crystal already has four sides above the girdle and four below. The corners are cut from all of these facets, producing eight four-sided facets on top (the crown) and eight more on the bottom (the pavilion). When the culet is cut, all the four-sided facets on the bottom become five sided.

3 There are 40 triangles (24 above, 16 below).

4 Five if you count mirror images as different, three, if you count them as the same.

5 I count 104 edges: 48 on the top, 16 around the girdle, and 40 edges on the bottom.

6 There are 48 intersection points. ◘◘

PHENOMENA

Just beyond a fragile curtain of interlaced fern leaves, a blood-red orb—the sun—hovers expectantly. A new day dawns on a Minnesota farmscape, and nature photographer R. Hamilton Smith recorded its earliest moments. This scene presented itself to him, not during one of his photographic field trips, but while spending some time working on a friend's farm. Barely up before sunrise, Smith was sitting in the farmhouse kitchen when he happened to glance out the window. Immediately the hulk of the rising sun slowly creeping up behind a cluster of delicate fern branches caught his eye. The contrast of the red hulk and delicate green leaves was too striking to pass up. So the next morning Smith arose even earlier and waited for the sun to appear. With a 105mm lens and a bellows unit attached to his Nikon F2, he recorded this image on Kodachrome 64 film. DO

COMING IN THE MARCH OMNI

INTERVIEW

Fellow scientists have called Roger Revelle "without peer" on problems requiring a balanced judgment of the earth's geology, chemistry, biology, and physics. His career has been entwined with the destiny of the Scripps Institution, which he joined in 1931 and later directed. Scripps made Revelle into an oceanographer, and Revelle made the ocean into big science. He was science adviser to President Kennedy, and for 20 years directed Harvard's Center for Population Studies. Today Revelle is an expert on the greenhouse effect, and in this Interview he tells us what to expect from the weather in the next 30 years and offers some views about motions in the oceans.

STARSCAPES

Long before NASA hurled camera-laden probes to the edges of our solar system, our views of space depended on an entirely different eye: the imagination of Chesley Bonestell, who for 35 years has been the dean of astronomical artists. Bonestell combines glazes and stippling with a fine sense of perspective to produce paintings so realistic that it is hard to tell his Fifties Saturn portraits from *Pioneer* photos. Tour the universe through the mind of Chesley Bonestell in *Omni*.

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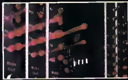


If Earth has truly become a global village, its epicenter may well be Newark, New Jersey. That's where you'll find EIES, short for the Electronic Information and Exchange System, the longest-running and most prestigious computer network in the world. The brainchild of computer scientist Murray Turoff, EIES has served a multitude of roles—from electronic meeting hall to a kind of new-age party line over which people forge both intimate and what Turoff calls cognitive relationships. For a remarkable glimpse into the future of networking, see the March *Omni*.

FICTION

Frank Herbert's *Dune* spawned the most successful science-fiction series ever. In March, *Omni* will publish an exclusive excerpt from the newest installment, *Heretics of Dune*. In it, a girl finds the courage and power to control the great Shaitan, a giant sandworm indigenous to her planet. Our second fiction piece is by Jere Cunningham, author of the horror novels *The Legacy* and *The Abyss*. He successfully combines his expertise in horror with traditional science fiction to create a terrifying story called "Fire." Archaeologists on the planet Xerxes discover an artifact that breeds obsession and creates dissension within the group. *Omni*'s third fiction selection also deals with obsession, but in a very different tone. Harvey Jacobs's darkly humorous "My Rose and My Glove" is about a businessman who is suddenly seized by the need to reclaim his toy motorcycle, which he traded to a friend long ago for a Howdy Doody ring. The friend agrees—but for a price.

Diamonds,
and games for the XLVIII Olympiad

GAMES

By Scot Morris

February is the month of valentines, hearts, and expressions of love and commitment. People haven't always given diamonds to seal an engagement. In some countries the tradition is quite recent. But today about 68 percent of American brides get engaged with a diamond ring. How much do you know about this most-precious of gemstones? Here's a quiz to test your knowledge.

GENERAL INFORMATION

1. Diamonds are found in volcanic stone called kimberlite. In the world's most productive mine (DeBeers's Premier Mine in South Africa), a ton of kimberlite yields a bit less than 0.002 ounce of diamonds—and only about 20 percent of the diamonds found are of gem quality. Most mines discard tens of tons of kimberlite for every carat of diamond. (A carat is 200 milligrams, or 0.2 gram.) The waste kimberlite is used for (a) construction, (b) landfill, (c) roadbeds, (d) nothing.

2. The average engagement-ring diamond seen today is more brilliant for a given weight than any diamond ever seen by Marie Antoinette. (a) True, (b) False.

3. India was the world's diamond source until the early 1600s. Then the world's supply virtually dried up, and there were no new diamonds until the discoveries in Brazil in 1775. Brazil's supply was depleted by the 1860s, which was just when the first diamonds were found in South Africa. South Africa remained the world's major source for over a century. Today most of the world's diamonds come from the USSR, though these are primarily industrial grade and not gem quality. Most of the diamond mining in this country is (a) in Hawaii, (b) in Alaska, (c) in Arkansas, (d) open to the public for $2 a day.

4. If you pay $500 for a diamond weighing 0.25 carat, how much would you expect to pay for a diamond of equal quality weighing one carat?
(a) $1,500, (b) $2,000, (c) $3,000, (d) $5,000, (e) $10,000, (f) $15,000.

5. How would you compare 18-*karat* gold to an 18-*carat* diamond?

6. The basic elements of a diamond's quality are expressed as "the four *C*s." Carat weight has already been mentioned. The other three are color, clarity, and cut. The most valued stones are colorless; the slightest tint, perhaps detectable only to trained eyes, is enough to downgrade the stone. The bottom of the scale is *X*, the top is *D*. When the scale was standardized, the letters then in use (*A*, *B*, and *C*) had become so confusing that it was decided to avoid them entirely.

The clarity of a stone is rated according to the number of blemishes that can be seen through a ten-power jeweler's loupe. The top of the line is called flawless or perfect. If a perfect stone is ranked 1 on the clarity scale, what rank do you suppose would go to a slightly imperfect stone?
(a) 2, (b) 3, (c) 4, (d) 5, (e) 6, (f) 7.

7. There may soon be a fifth *C* to consider in valuing a diamond: a certificate accompanying the jewel that tells whether it is natural or man-made. Gem-quality diamonds can be created ("grown"), but so far not economically. A synthesized diamond may cost three or four times as much to make as an equivalent natural stone costs. Even if production costs are made competitive, natural diamonds will command a much higher price, for the same psychological reasons that real fur coats cost more than artificial fur and that natural rubies and sapphires are much more expensive than comparable quality synthetic versions. The first company to create a synthetic diamond was (a) DeBeers Consolidated Mines, (b) Mitsubishi, (c) Du Pont, (d) Exxon, (e) 3-M, (f) Sony, (g) General Electric.

8. An ounce of gold was valued recently at about $500. What would the same weight in top-quality cut diamonds cost?
(a) $1,000, (b) $5,000, (c) $10,000, (d) $50,000, (e) $100,000, (f) $500,000, (g) $1,000,000, (h) $5,000,000.

GEOMETRY

Diamonds are made by applying pressure to carbon. The pressure can be exerted over millions of years or over a few seconds. You can make a diamond out of any kind of carbon—from the graphite in a pencil to a charcoal briquette.

The way a diamond is cut is critical. Sometimes a poorly cut stone can be given a face-lift and double or treble in value while losing 20 percent or more of its weight. The world's most popular cut is the brilliant, shown at right. Although diamond cutters had approximated this shape through experience, it was not until 1919, when Marcel Tolkowsky published a theoretical paper on the subject, that the optimal cut was defined with angles to fractions of a degree and proportions to within a fraction of a percentage point.

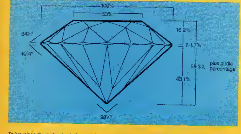
There are two objectives in cutting a diamond: maximizing life and fire. Life is the amount of light entering a gem that is reflected out the top facet, toward the eye of the viewer and not in some other direction. Fire is the degree to which the gem disperses light, that is, turns white light into a rainbow of colors. As it happens, the two properties are reciprocal: as one increases, the other decreases. Tolkowsky showed how to achieve optimal brilliance, the best compromise between life and fire.

Done right, an octahedral diamond crystal can be turned into a Tolkowsky brilliant after cutting away no more than 60 percent of the rough stone's weight. The final gem has exactly 58 facets—no more, no less. The stone's circular rim, the girdle, is usually considered to be a 16-sided polygon with no differential facets of its own. The largest facet is the top, or table. The smallest is at the bottom tip, the culet, which is cut flat to prevent chipping.

Given what you know about octahedrons and what you can gather from the illustration, answer the following questions.

1. Of the 58 facets, how many are on the top half of the diamond, and how many are on the bottom?
2. Of all facets, how many are four-sided?
3. How many are triangular?
4. Of all the triangles, how many *different shapes* are there?
5. How many edges?
6. How many intersection points?

Answers are on page 115.



Tolkowsky's theoretical cut, the world's most popular diamond. It has 58 facets—no more, no less

COMPETITION #32 OLYMPICS 2084

This July athletes from all over the world will descend on Los Angeles for the XXIII Olympic games. What will the games be like in another century? By the time of Olympics 2084 we anticipate that a number of events will take place off the earth—in space on the moon and in space habitats. Events such as these:

Lunar hurdles. In one-sixth gravity, running and jumping will require different skills from those required on Earth. Sprinters will have to lean forward with chests just off the ground. In order to keep their feet from "running out from under them." We anticipate that the fastest runners will keep their feet pointed outward and their knees spread out frog-fashion. In jumping, they will be able to raise their centers of gravity six times higher than on Earth. The soaring headfirst leaps over hurdles will be reminiscent of the earthly sport of ski jumping.

Spacemінton. This is played with a standard badminton bird in a transparent, zero-g chamber in a space station. Stretched across the center of the chamber is the net, with an Olympic-size central hole that's only one meter in diameter. Through practice, players have learned how each swing at the bird will make their bodies twist and turn, and they adjust each trajectory across the playing field. When a player reaches the side, he or she does a flip turn like a swimmer or touches the wall with the racket and pushes off with one of the springs built into its rim.

3-D Water Polo. In this weightless game each five-member team tries to drive a ball through the pneumatic rubber ring mounted at the opponent's end of the pool, a huge transparent sphere filled almost entirely with water. Players may get their air from a large bubble at the center of the tank, or from one of the "panic ports" around the rim of the sphere. (This costs a player one minute in the penalty box.)

America's Space Cup. This solar sailing race around the moon—from low Earth orbit (LEO) to translunar orbit and back—has become an intense rivalry between the Australians and the California-Americans. Using their kilometers-wide solar sails, the "sunjammers" begin months before the Olympiad so that the finish will be held during Olympic week.

After collecting solar power on the first leg, they retrim their sails to modify their trajectory for the return to LEO.

And what else? *Omni*, in collaboration with the Los Angeles chapter of the American Institute of Aeronautics and Astronautics (AIAA), announces a contest for proposed sporting events to be held a century from now off the earth.

Describe an Olympic event to take place in space and send illustrations of your idea. Entries will be judged by the *Omni* games editor, by William Haynes and Ed Goldstein of the Los Angeles AIAA, and by former astronauts Buzz Aldrin and Gordon Cooper.

Two or three grand prize-winners will be chosen: One on the basis of a prose game description and one on the basis of drawing or drawings of outer-space sporting events. If the judges decide it is warranted, a third grand prize will be awarded to the entry that most effectively combines a written description with a visual representation.

Grand prize winners will be flown to Los Angeles the weekend of July 20 to 23 to be the guests of honor at the AIAA's Space Week luncheon, at which Buzz Aldrin will be a featured speaker. Then, on Saturday, July 21, they will attend the grand-opening reception for the new California Museum of Aerospace Science. The rest of the weekend, they will be given VIP tours of such local attractions as the Jet Propulsion Laboratory, Rockwell International's space shuttle mock-up, and Hughes Aircraft's flying boat, the "Spruce Goose."

In addition, five runners-up will receive cash prizes of $50 each, and the best entries will be placed on special display at the California Museum of Aerospace Science during the first weeks of its grand opening, which will coincide with the 1984 Olympics. The winners will be featured in the July 1984 issue of *Omni*.

Enter once only, please. Send any number of illustrations (preferably color slides—we'll contact you for originals) and/or no more than one double-spaced, typed page of description (about 250 words). Send entries postmarked by March 10, 1984, to *Omni* Competition #32, 1965 Broadway, New York, NY 10023-5965. All entries become the property of *Omni*; none will be returned. **OO**

LAST WORD

By James Gorman

"Gray holes are sucking dust out of these other universes and dumping it in ours. That means we are another universe's dust bag, and vice versa."

Recently I was reading Plato (*The Timaeus*), and it turned out Plato said a great thing. It wasn't about the myth of the cave or about our world being a watered-down version of Platonic ideals (that's fairly obvious). The great thing Plato said was this: "The universe was created without legs and without feet."

There it is—a completely comprehensible statement by a major thinker about the physical nature of the universe. Not like the things a modern cosmologist is likely to talk about: curved space-time or quantum gravity.

And Plato was right. Well, I guess it would be more accurate to say he wasn't wrong. It is true that the universe doesn't have feet, but then neither does the World Trade Center or the Sistine Chapel.

Okay, it wasn't one of his better thoughts. But at least you could understand what he was saying. Legs and feet? Yes or no. Any guy in the agora could have an opinion about it. These days scientists know more than Plato did, so they say. But no one knows what the scientists are talking about. Science has become much too hard.

Most of us are completely confused. I am absolutely certain that Ronald Reagan does not understand quantum gravity, and what kind of science is it that even the President cannot understand? We need better science—science that the President and I can grasp. Most important, we need a science that addresses questions people really want answered. We've answered other such questions, like How far away is the sun? and What is gravity? Here are a few more to consider.

Dust. Think about it. You vacuum a room, close all the windows and doors, and go on vacation. When you come back, there will be dust. Even if you vacuum it again and go on another vacation, when you come back there will be more dust. Why? Where does the dust come from? And why do we have to spend our lives pushing it around to get it off the shelves when we know it is only going to come back?

Socks. We all know where they come from, but where do they go? The story that they are mistakenly left in the washing machine or dryer is false. I myself have put carefully collated, matched pairs of socks into a dryer, kept guard during the entire cycle, and still taken out a pile of completely unmatchable objects that didn't even fit my feet. Someone should look into this.

Pens. The same question. Where are they all? I once put down an expensive pen on my desk, turned my back to look out the window, and when I turned around, it was gone. There was no one else in the room, and the door was locked. Yet that pen and countless others have never been found. Why?

Shirt labels. I mean the ones that appear in the back of the neck of men's shirts after they come back from the laundry. Who makes up the combination of letters that are supposed to designate your shirts and not someone else's? What linguistic principles are involved? Are shirt launderers from another planet? And are they the source of those odd-colored shirts that no human being would wear, the ones that occasionally appear in place of my nice blue button-downs?

I could go on—about keys or the single earring problem—but why bother? Scientists don't care. They prefer tackling elaborate problems and offering complicated solutions, like black holes, which are so confusing that I can't even tell whether they are a problem or an answer. We don't need black holes to solve the problems of mystery dust and missing socks. We need something simple, more in Plato's line of thinking. I myself happen to have a solution.

Gray holes. That's my idea. There are these gray holes, lots of them. They're like black holes, only smaller and weaker. They too are like vacuum cleaners and suck in everything that gets close to them, but they are the size of pinheads and only as powerful as three or four Hoovers. Unlike black holes, gray holes get clogged easily and dust accumulates around them, so those dust monsters you find clustered under your furniture are actually gray holes.

I know that doesn't explain the missing socks and the origin of dust yet, but I'm getting to that. You see, there are these other universes, lots of them. And they all have these gray holes. What happens is that their gray holes suck dust out of these other universes and dump it in ours. That means we are another universe's dust bag, and vice versa.

This could explain everything. No doubt, someone in another universe is, at this very moment, writing a thank-you note with my gold pen sucked onto his desk by a gray hole. And some creature that we wouldn't even consider intelligent is wearing my socks and shirts while I am forced to wear his.

We could be living with atoms and DNA and stuff that other universes have thrown out or misplaced. This could explain the origins of life. And maybe gray holes are behind the experiences people have when they are about to die but don't. It's people in another universe, who are sick and tired of getting all of our junk, waving them back.

I know the theory isn't perfect. I know that cosmologists would say that it conflicts with general relativity or something. And we still have to figure out how the dead people and the pens get through those little holes. But all things considered, I think it makes pretty good sense. And as ideas go, it's as good as Plato's. Isn't it? ◻◻

James Gorman, author of First Aid for Hypochondriacs (Workman Publishing Company, 1982), does not have a Ph.D. in anything.